AN EXPERIMENTAL STUDY ON THE IMPACT OF INTERIOR LIGHTING CONDITIONS ON PLANT GROWTH

V.A.D. ANUTHTHARA[1], SAJEEVI SILVA[2]*, MALSHA MENDIS [3] & CHAMEERA UDAWTTHA[4]
[1,2,3] NSBM Green University, Pitipana, Homagama, Sri Lanka
[4]University of Sri Jayewardenepura, Nugegoda, Sri Lanka
[1]vadanuththara@students.nsbm.ac.lk, [2]sajeevis7233@nsbm365.onmicrosoft.com
[3]malsha.m@nsbm.ac.lk, [4]Udawatthe@gmail.com

Abstract: This study investigates various intensities of artificial light from LEDs that could affect houseplants' growth and support biophilic interior design in residential apartments. Three species, including Aglaonema modestum, Philodendron hederaceum, and Alocasia amazonica, were exposed to low (20W), medium (36W), and high (50W) LED light continuously for 24 hours over a 14-day period in a controlled apartment-like setting. Visual observations were made on leaf health, new leaf emergence, general growth, and visible stress reactions. Outcomes demonstrated that Aglaonema and Philodendron grew well under low and medium light, maintaining healthy foliage with minimal stress, while Alocasia showed clear signs of stress under medium and high intensities. High-intensity lighting also triggered the infestation of Aglaonema with scale insects. The overall findings emphasize the adjustment of artificial lighting intensity to the needs of a specific species. This study gives practical information in residential interior design by enhancing plant health, aesthetic value, and identifying factors in the physical environment that may impact stress in plants indoors.

Keywords: *Biophilic design, Artificial Lighting, Apartment Interiors, Indoor Plant Light Intensity*

1. Introduction

Rapid urbanization has weakened the human–nature connection, reducing well-being due to limited access to green spaces and smaller living environments. (Browning, W. D., Ryan, C. O., & Clancy, J, 2014). Biophilic design responds to fill this gap by integrating natural elements such as plants, daylight, and ventilation into interior spaces to provide psychological restoration and improved emotional health (Kellert, S. R, 2018). Indoor plant cultivation has become one of the most popular approaches to the problems of apartment living and aesthetics with significant emotional and cognitive gains. Houseplants support stress reduction, emotional balance, and mental comfort-all of which reinforce the biophilia hypothesis that people have an innate tendency to affiliate with natural systems (Yin, J., et al., 2020). However, apartment interiors often receive insufficient levels of natural light, and artificial lighting for maintaining plant vigor becomes essential. While artificial lighting has been in broad use for indoor horticulture, few studies have explored the impact of 24-hour continuous artificial lighting on plant health in domestic settings (Paradiso, R., & Proietti, S., 2022). This paper addresses this knowledge gap by investigating the growth responses and stress of common houseplants to different LED lighting intensities under controlled, apartment-like conditions. By exploring the species-specific performance under different levels of artificial lighting, the study aims to provide evidence-based guidance for apartment residents and interior designers on optimizing indoor plant care through biophilic lighting strategies that enhance ecological and psychological well-being.

Research Question
What are the best LED lighting conditions (intensity and illuminance) for indoor apartment settings to achieve maximal plant growth?

Purpose and Objectives of the Study

- To compare the growth performance of indoor plants under warm white LED artificial light andatural outdoor sunlight exposure in apartment conditions
- To evaluate the impact of different LED light intensities and illuminance on plant growth.
- To identify a lighting design solution on plant growth

2. Literature Review

2.1. BIOPHILIC DESIGN AND INTERIOR PLANTS

Biophilic design emphasizes a human inclination or instinct to return to nature, which has several psychological and

*Corresponding author: Tel: +94 777414977 Email Address: sajeevis7233@nsbm365.onmicrosoft.com
DOI: https://doi.org/10.31705/FARU.2025.16

physiological advantages, especially in small-sized modern apartments with minimal access to the outdoors((Kellert, S. R., 2018) Indoor plants serve as living biophilic components that would help in improving visual comfort, reducing stress, and offering indoor environmental quality ((Bringslimark, Hartig & Patil, 2009). Some of the fundamental biophilic features include direct nature, which pertains to living plants; indirect nature, referring to natural materials such as wood and stone; and symbolic nature, which describes organic patterns in textiles or wallpaper.

Indoor-suitable plant species, such as Alocasia amazonica, Aglaonema modestum, and Philodendron hederaceum, are widely used because of their tolerance and aesthetic contribution to interior spaces (Specht et al., 2020). The selection of the plant species becomes crucial with respect to the result of biophilic goals: plants are diverse in light tolerance, in preferred humidity, and in growth behavior, which affects design intentions and environmental performance.

2.2. LIGHTING FOR INTERIOR PLANT GROWTH IN APARTMENT

Light is the most dominant factor in plant photosynthesis and as such plays an important role indoors, where, depending on building orientation, window size, or urban density (Poorter et al, 2019), very low levels of sunlight usually exist. Artificial lighting-LED systems especially-has become the preferred solution for indoor plant maintenance because LEDs emit variable spectra, low heat emission, and can make high energy efficiency (Bantis,Smirnakou,Ouzounis, 2018).

Artificial lighting in biophilic interiors compensates for insufficient daylight inside but also supports plant health, aesthetic vibrancy, and long-term survival. LEDs with adjustable intensity and spectral distribution enable indoor ecosystems to be sustained effectively even in apartments with minimal natural light penetration.

2.3. LIGHT DURATION, CIRCADIAN RHYTHMS

Photoperiod has an impact on the regulation of circadian rhythms, morphology, and metabolic processes (Devlin & Kay, 2001)of plants. Most indoor tropical species require 12-16 hours of photoperiod due to the requirements that meet their ecological conditions (Taiz et al., 2015)naturally. Inconsistent or inadequate photoperiod usually leads to poor growth and physiological stress.

Smart Lighting controls, timers, and reflective materials are some of the most common recommendations in literature for optimizing light uniformity and improving energy efficiency indoors (Bantis,Smirnakou,Ouzounis, 2018).in controlled agriculture, continuous lighting has been researched; some species have proven to be resilient or even to produce more with extended lighting (Velez-Ramirez, A. I., 2014), showing that some plants can tolerate artificial lighting for longer-than-usual periods though their tolerance to this varies from species to species.

2.4. CONDITIONS FOR PLANT GROWTH IN APARMENT

Successful growth of indoor plants relies on several environmental factors, such as soil composition, humidity, temperature, and air circulation (Taiz, 2018). Most tropical indoor plants prefer well-aerated substrates, moderate moisture, and stable indoor climates. The most common favorable range for normal growth falls within a temperature of 18°-26°C and relative humidity (Poorter et al, 2019) between 50-70%.

Indoor conditions in apartments tend to fluctuate due to limited space and ventilation, creating a particular need for adjustments like the rise in humidity, improvement in air flow, and the stability of moisture levels. Management of the environmental conditions in this regard becomes highly important for the plants to maintain their vitality and help support biophilia design outcomes within constrained residential interior settings.

2.5 IMPACT OF LIGHT INTENSITY AND QUALITY ON PLANT GROWTH

Light intensity and spectral quality are major environmental factors influencing plant morphology, photosynthesis rate, and coloration. Blue wavelengths (430-450 nm) support leaf expansion and stomatal activity, while red light wavelengths (640-660 nm) promote photosynthetic efficiency and overall biomass accumulation (Taiz, 2018). A balanced combination of red and blue light is common in indoor horticultural systems.

LED grow lights can provide sufficient intensities indoors; distance must be a consideration in artificial lighting setups because light intensity decreases with the inverse square law (Hogewoning et al., 2010). Properly configured lighting systems can enable healthy growth, even in enclosed apartments, to support a broader biophilic design practice.

3. Research Methodology

This study investigates the influence of artificial light intensity on the growth performance and physiological response of indoor plants under simulated apartment conditions. The methodology integrates both quantitative and qualitative approaches to provide a comprehensive understanding of plant adaptation to artificial lighting. The experiment was conducted over a period of 14 days, under controlled interior environmental conditions, to evaluate variations in growth rate (Plant Height, number Of Leaves), leaf development, and visible stress symptoms across different light intensity levels.

Experimental Design and Process: A mixed-method approach was employed, combining measurable quantitative growth data with qualitative visual assessments of plant health. The experiment was designed to simulate continuous exposure to artificial lighting, representing extreme indoor apartment conditions where natural daylight is limited. To ensure consistency, all plants were subjected to constant illumination for 24 hours per day throughout the 14-day testing period. Observations were recorded twice daily to monitor progressive growth behavior, leaf formation, and any signs of stress or infestation.

Plant Selection and Preparation: Three species of commonly cultivated indoor plants Alocasia amazonica, Aglaonema modestum and Philodendron hederaceum were selected based on their popularity in Sri Lankan apartments, varied light tolerance levels, and low maintenance requirements (Figures 1). Each specimen was potted in standardized 12 cm diameter containers containing a growing medium mixture of cocopeat, vermicompost, and river sand in a 2:1:1 ratio. This soil composition was chosen to ensure adequate aeration, drainage, and nutrient balance suitable for indoor plant cultivation.

a) Alocasia amazonica b) Aglaonema odestum c) Philodendron hederaceum

Figure:1 *Representative indoor plants from the Araceae family.*

Figure:**2** Experimental setup showing the arrangement of three Araceae species under controlled indoor lighting conditions.

Experimental Setup and Environmental Control: The trial was conducted within an urban apartment room in Sri Lanka, designed to replicate realistic indoor living conditions. Each plant species was placed within a wooden-framed reflective chamber to ensure even light distribution and minimize external light interference. Three LED lighting setups were used to represent low (5,000–10,000 lux), medium (15,000–25,000 lux), and high (30,000–40,000 lux) intensity conditions, measured 60 cm above the plants to represent the intensity of lighting in illuminance levels. A separate control group was maintained outdoors under natural sunlight to serve as a comparative baseline.

Temperature and humidity were carefully regulated to maintain stable interior conditions, with temperature levels ranging from 24°C to 28°C and relative humidity between 45% and 65%. These parameters reflect typical apartment microclimates in tropical urban contexts. Regular monitoring ensured that all test conditions remained consistent across the experiment.

Data Collection and Observation Parameters: Data were collected through systematic observation twice daily over the 14-day period. Quantitative measurements included plant height, number of leaves, and leaf area expansion, which were recorded using a standardized scale and digital caliper for accuracy. Qualitative assessments focused on visual indicators such as leaf color, texture, and the presence of stress symptoms including wilting, discoloration, or pest infestation. Particular attention was given to detecting scale insect presence in Aglaonema modestum and chlorosis in Alocasia amazonica, as these were early indicators of lighting stress. Through this controlled experimental procedure, the study aimed to identify optimal artificial light intensities that promote healthy vegetative growth while minimizing stress in common indoor plants. The collected data provided a foundation for evaluating how light intensity can be effectively managed within biophilic interior design strategies to support both ecological sustainability and occupant well-being.

4. Results and Discussion

4.1 QUALITATIVE ANALYSIS
The qualitative observations examined the visual growth response of *Aglaonema modestum*, *Philodendron hederaceum*, and *Alocasia amazonica* under varying artificial light intensities. Morphological changes such as leaf color, variegation, and texture were recorded throughout the 14-day experiment. The overall growth differences of the plants were analyzed by comparing each plant's growth under LED lighting with its natural growth observed in the control group maintained outdoors under sunlight. Among the three species are illustrated in **Figure 3,** which presents their qualitative characteristics under controlled indoor conditions.

Aglaonema modestum (Low Light): Displayed improved leaf coloration and typical variegation patterns with no height increase or new leaves. The plant showed good tolerance to low light, maintaining healthy pigmentation without stress signs.

Philodendron hederaceum (Medium & High Light): Under medium light, new leaves unfurled slowly with healthy petioles. Under high light, leaf development was faster and more robust, with no signs of damage or stress, indicating a positive response to higher light intensity.

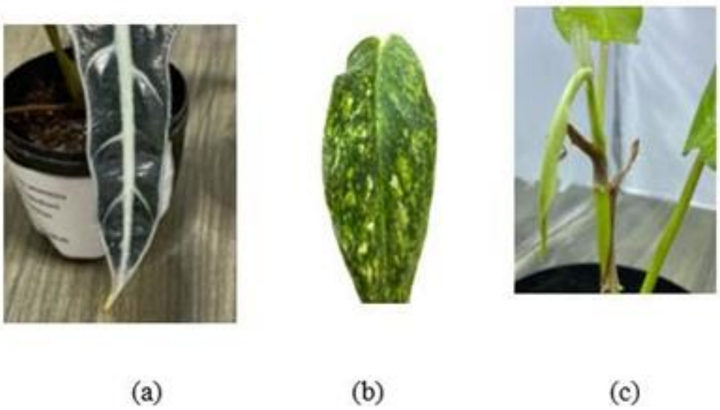


Figure:3 Visual observation of selected *Araceae* species used in the study
(a) Alocasia amazonica, (b) Aglaonema modestum, and (c) Philodendron hederaceum demonstrating qualitative growth characteristics under indoor conditions

Table 1: Symptom Summary by Light Intensity

Light Intensity	Observed Plant Responses
Low Intensity	• Limited overall growth. • Alocasia exhibited slight tip necrosis. • Aglaonema remained healthy with stable leaf coloration. • Mild stress symptoms occurred only in more sensitive species.
Medium Intensity	• Aglaonema developed tip browning and leaf yellowing indicating moderate stress. • Philodendron showed minor dry leaf tips but no severe stress. • Growth was generally supported with only minimal cosmetic issues.
High Intensity	• Aglaonema displayed mechanical damage (necrotic holes) and severe scale insect infestation (likely unrelated to light intensity). • Philodendron exhibited minor dark spots without significant stress.

4.2 QUANTITATIVE ANALYSIS
Plant Height under Different Light Conditions- The study compared the variation in plant height of Philodendron hederaceum and Aglaonema modestum under four lighting conditions low, medium, high, and natural sunlight over a 14-day period. At the start of the experiment, all plant samples were standardized to a height of 20 cm to ensure uniformity. Over time, Aglaonema modestum showed optimal height increase under low and medium LED light intensities, while Philodendron hederaceum demonstrated greater vertical growth under medium and high light levels (Chart 1 & Chart 2). These findings indicate that moderate light levels promote stable growth, while excessive illumination may accelerate elongation but risk inducing stress symptoms.

Number of Leaves under Different Light Conditions- Leaf count analysis revealed that plants grown under artificial LED lighting exhibited a notable increase in leaf number compared to those exposed to natural sunlight. This suggests that regulated artificial lighting supports higher vegetative activity and adaptability by providing consistent light exposure. In contrast, plants under natural light displayed minimal or negative changes, likely due to environmental stress and fluctuating sunlight intensity. The comparative results before and after the experiment are illustrated in Chart 3 and 4, respectively.

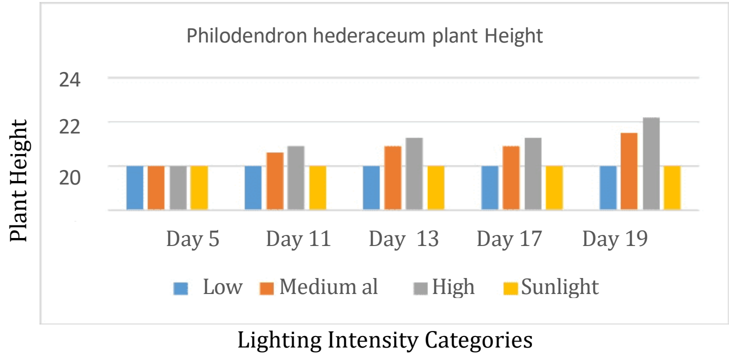


Chart1: Variation in Philodendron hederaceum plant height measured under four lighting conditions—low, medium, high, and natural sunlight over a 14-day observation period.

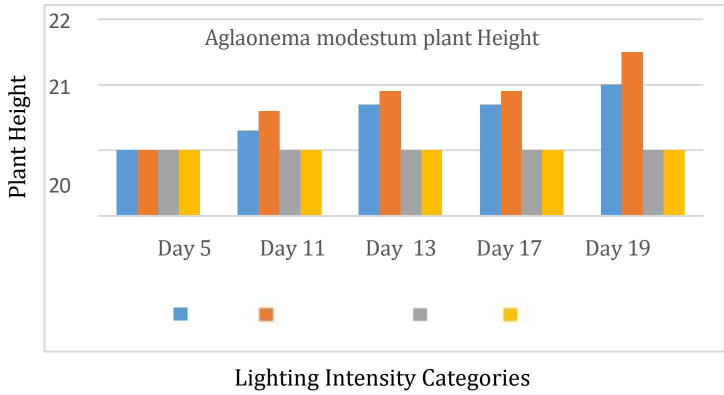


Chart 2: Variation in Aglaonema modestum plant height measured under four lighting conditions—low, medium, high, and natural sunlight over a 14-day observation period.

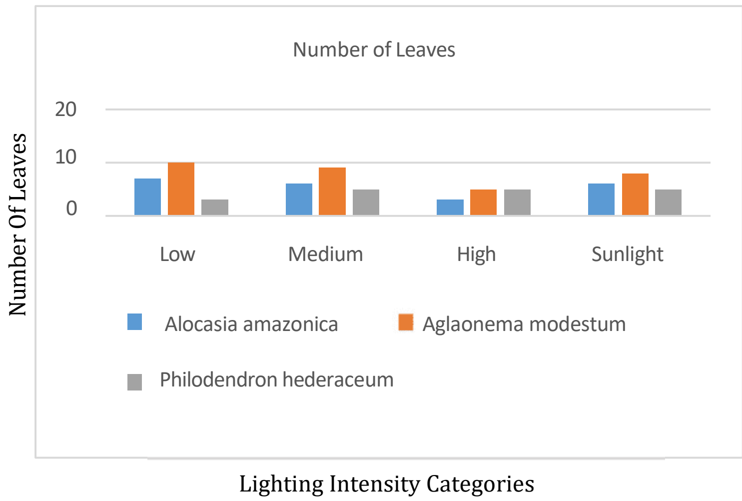
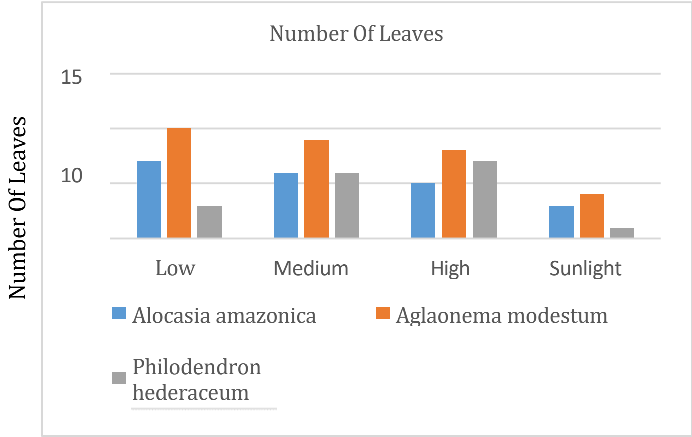


Chart 3: Number of leaves of three *Araceae* species under different lighting conditions before the experiment.

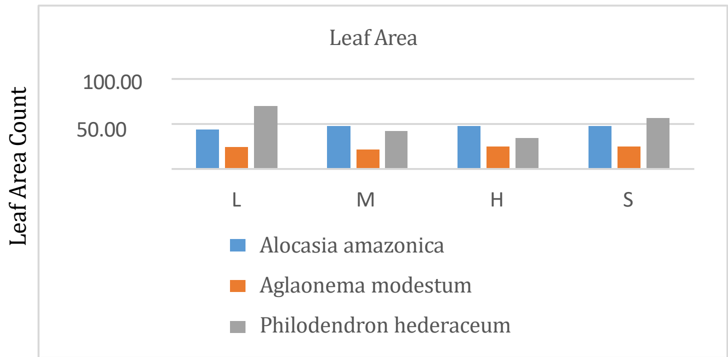
Leaf Area Across Light Conditions- The comparison of leaf area among Alocasia amazonica, Aglaonema modestum, and

Philodendron hederaceum under varying artificial lighting intensities demonstrated a strong positive response to medium LED light levels (Chart 5 and 6). Plants under natural sunlight produced smaller leaves, likely due to direct heat exposure, inconsistent light duration, and partial leaf desiccation. Conversely, indoor plants under regulated artificial light exhibited broader and healthier leaf surfaces, indicating more efficient photosynthetic activity and optimal growth performance in controlled interior environments.



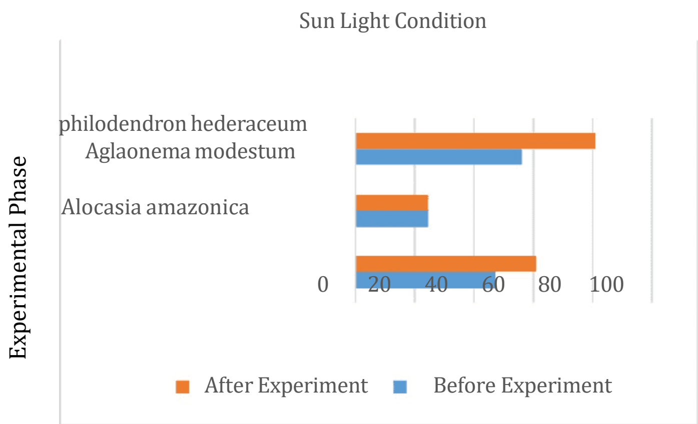
Lighting Intensity Categories

Chart:4 Number of leaves of three *Araceae* species under different lighting conditions after the experiment.



Lighting Intensity Categories

Chart:5 Comparison of leaf area in three *Araceae* species (*Alocasia amazonica*, *Aglaonema modestum*, and *Philodendron hederaceum*) under varying artificial lighting intensities (Low, Medium, High).



Leaf Area Count

Chart:6 Comparison of leaf area in three *Araceae* species (*Alocasia amazonica*, *Aglaonema modestum*, and *Philodendron hederaceum*) under natural sunlight conditions.

4.3 FINDINGS

The findings of this study propose a practical biophilic lighting strategy for apartment interiors that integrates both human visual comfort and plant health requirements. As illustrated in Figure 9**,** The results indicate that a combined lighting approach utilizing photosynthesis-supportive task lighting alongside ambient warm white illumination can effectively sustain indoor vegetation while maintaining a visually pleasant environment for occupants.

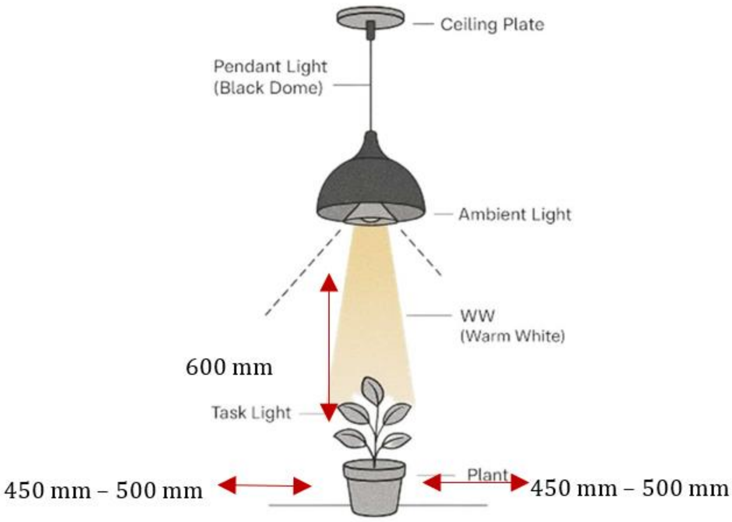


Figure:4 Finding Lighting Design with Requirements

This dual-purpose lighting configuration allows artificial light to serve both aesthetic and functional objectives. . The photosynthetic task lighting ensures that plants receive the optimal light spectrum and intensity necessary for healthy growth, while the ambient warm white lighting contributes to a comfortable and psychologically soothing atmosphere, reinforcing the principles of biophilic design. Importantly, this solution can be implemented within existing apartment structures without major modifications or the need for specialized horticultural grow lights.

By balancing ecological and human-centered design considerations, the proposed system enhances the integration of nature within compact residential environments. It promotes sustainable indoor greenery maintenance, improves indoor environmental quality, and supports the psychological well-being of occupants, demonstrating how biophilic lighting can be both an aesthetic and functional design innovation for urban apartments.

5. Implications, Limitations, and Future Research

The results of this experiment show that controlled LED lighting can significantly enhance indoor potted plant growth and vitality in apartment interiors and provide practical guidance for implementing biophilic design to improve both plant health and human well-being. Most species tested were found to thrive under medium-intensity LED light, between 15,000 to 25,000 lux, while low-intensity light promotes the health of shade-tolerant plants. However, the short 14-day experimental period, the experimentation with only three plant species, and the use of chosen LED light intensities themselves limit the comprehensiveness of the study. Continued research might be done on a wider variety of plants, their long-term growth, using different light spectrums, and considering other ambient factors such as humidity, temperature, and soil composition. The integration of occupant perception and psychological responses would provide further insight into the benefits of biophilic lighting in residential interiors. These findings can serve as the basis for developing evidence-based interior lighting strategies and can help provide actionable guidance for apartment dwellers and designers interested in optimizing indoor plant performance to create healthier, more sustainable, nature-connected living environments.

6. Conclusion

This study examined the relationship between a biophilic element indoor plants and its artificial substitute LED lighting in apartment interiors. The findings demonstrated that well-calibrated LED lighting can significantly support plant health while enhancing environmental quality and human well-being in compact residential spaces. Through controlled experimentation, the successful support of indoor plant growth using LED lighting was observed, demonstrating how artificial lighting can act as a substitute for natural light to maintain the benefits of biophilic elements in apartment interiors, particularly in the use of artificial lighting to sustain plant growth and maintain visual comfort. The findings revealed that LED lighting, when applied with appropriate intensity and spectral balance, significantly improves plant health, promoting leaf development and overall vitality. This confirms that lighting is not only an aesthetic consideration but also a critical environmental factor in sustaining indoor ecosystems. Moreover, the results reinforce that moderate artificial lighting can effectively substitute for natural light in apartment settings, supporting plant photosynthesis while maintaining occupant comfort.

From a design perspective, these outcomes provide valuable guidance for interior designers and architects seeking to integrate nature-based solutions into modern living environments. The adoption of dual-purpose lighting serving both visual and vegetative functions present an efficient and sustainable approach to biophilic design. Ultimately, this study underscores the potential of integrating artificial lighting systems that enhance both plant performance and human experience, contributing to healthier, more sustainable, and psychologically restorative apartment interiors.

7. References

1. Bantis,Smirnakou,Ouzounis. (2018). Bantis, F., Smirnakou, S., Ouzounis, T., Koukounaras, A., NtCurrent status and recent achievements in the field of horticulture with the use of light-emitting diodes (LEDs). *Scientia Horticulturae*.
2. Browning, W. D., Ryan, C. O., & Clancy, J. (2014). 14 Patterns of Biophilic Design.
3. Calabrese, E. F, & Kellert, S. R.,. (2015). The practice of biophilic design. Terrapin Bright Green.
4. Dou, H., Niu, G., Gu, M., & Masabni, J. (2017). Responses of basil plant growth and morphology to different light intensities. HortScience. 1562–1566.
5. Hogewoning et al. (2010). demonstrated effects of blue-containing LED light and red/blue light combinations on leaf morphology, chlorophyll content, and photosynthetic performance.
6. Kellert, S. R. (2018). Nature by design: The practice of biophilic design. yale university press.
7. Mitchell, C. A. (2015). LEDs for energy-efficient horticulture. Acta Horticulturae. 509–515.
8. Paradiso, R., & Proietti, S. (2022). Light-quality manipulation to control plant growth and photomorphogenesis in greenhouse horticulture: The state of the art and the opportunities of modern LED systems. *Journal of Plant Growth Regulation*, 742-780.
9. Poorter et al. (2019).
10. Söderlund, J. N. (2015). Biophilic architecture: A review of the theory and practice. *Sustainability*.
11. Taiz, L. ,. (2018). Plant physiology and development.
12. Velez-Ramirez, A. I. (2018). Plants under continuous light: a review on the positive and negative effects of continuous light in Arabidopsis, tomato, and other crops. *Plant Science*.
13. Yin, J., et al. (2020). Effects of biophilic indoor environment on stress and anxiety recovery: A between-subjects experiment in virtual reality. *Environment international,*.