iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 **Issue:** XII **Month of publication:** December 2025

DOI: https://doi.org/10.22214/ijraset.2025.76178

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue XII Dec 2025- Available at www.ijraset.com

Algae-Based Paints: A Sustainable Approach to Pigments, Coatings, and Interior Applications for Artisan and Handloom Studios

Leenu Malviya[1], Sucheta Nigam[2]
[1]*Design Student, Sanjeev Agrawal Global University, (SAGE), Bhopal*
[2]*Associate Professor, Sanjeev Agrawal Global University (SAGE), Bhopal*

Abstract: ***The growing demand for eco-friendly materials in architecture, interior design, and product manufacturing has sparked interest in algae as a renewable source of pigments and functional additives for paints and coatings. Algae-based paints are gaining attention as sustainable alternatives to conventional synthetic paints due to their renewable sourcing, low environmental impact, and natural antimicrobial properties. This review synthesizes research on the use of algae-derived pigments and biomass in paints, examining their extraction ,methods, antimicrobial and antifouling efficacy, thermal stability, practical applications, formulation, performance, sustainability, and commercialization potential. Findings highlight algae's versatility in providing natural hues, bioactive functionalities, and environmental benefits compared to synthetic alternatives. Limitations such as biodeterioration and pigment stability are also discussed. Adaptation of algae-based paints for interior and industrial uses shows considerable promise for eco-friendly coatings. However, challenges such as pigment stability, scalability, and cost competitiveness remain. The paper concludes with research gaps and future directions for the development of algae-based paints.***

Keywords: Algae-based paint, sustainable coatings, natural pigments, antimicrobial paint, antifouling, bio-based polymers.

I. INTRODUCTION

Interior design has increasingly evolved beyond aesthetics into a discipline centered on environmental responsibility, user well-being, and cultural relevance. As global awareness of climate change, resource depletion, and indoor pollution grows, the design industry is shifting toward materials and methods that minimize ecological impact while improving human health. One of the major contributors to indoor air pollution is conventional petroleum-based paint, which contains volatile organic compounds (VOCs) responsible for respiratory disorders, eye irritation, chemical sensitivity, and long-term environmental degradation. According to numerous environmental health studies, indoor environments can contain VOC concentrations up to ten times higher than outdoor levels, making material selection a critical design decision. In response to this challenge, bio-based materials—particularly algae-derived paints—have emerged as promising sustainable alternatives. Algae-based paint is produced using pigments extracted from microalgae, a rapidly renewable biomass known for its carbon-absorbing capacity. Microalgae require minimal resources to grow (sunlight, water, and CO_2), and their pigments offer natural coloration, biodegradable properties, antimicrobial characteristics, and near-zero VOC emissions. These qualities position algae-based paints at the intersection of material innovation, environmental sustainability, and biophilic design. They not only reduce the carbon footprint of interiors but also contribute to healthier indoor environments by eliminating toxic additives. The relevance of algae-based paints becomes even more significant within artisan- and craft-based workspaces. India's handloom sector—one of the world's largest—relies heavily on traditional knowledge, cultural heritage, and manual skill. Handloom artisans often spend long hours in enclosed studio environments where air quality, natural light, and thermal comfort directly influence productivity, creativity, and well-being. Poorly ventilated, chemically treated environments can hinder the craft process and negatively affect artisans' physical health. Therefore, integrating eco-friendly materials such as algae-based paints into artisan studios offers dual benefits: improved environmental performance and enhanced support for cultural and craft-driven livelihoods. Maheshwar, a historic town in Madhya Pradesh known for the renowned Maheshwari saree, provides a culturally rich context for exploring these material innovations. The region's deep-rooted weaving traditions and climatic conditions—hot summers, high humidity, and dense workspaces—make it an ideal site to test the potential of algae-based coatings. By incorporating algae-based paint into the proposed Studio for Handloom and Artisan Revival, the study seeks to bridge traditional craft heritage with contemporary sustainable design practices.

©IJRASET: All Rights are Reserved

This research, therefore, aims to evaluate the environmental, aesthetic, and cultural performance of algae-based paints and demonstrate their integration within an artisan-centric interior. Through a combination of literature review, case study analysis, site observations, and design development, the study provides new insights into how bio-derived materials can support the future of sustainable interior design, particularly in heritage craft ecosystems. The introduction of algae-based paint is not merely a material substitution—it represents a shift toward a holistic design approach where ecological responsibility, cultural preservation, and human well-being coexist harmoniously.

II. LITERATURE REVIEW

A. *Composition and Development of Algae-Based Paints*

Microalgae provide naturally derived pigments that can be processed into environmentally safe, biodegradable coatings. Previous studies (Abd El-Gawad et al., 2021; Prathiksha et al., 2023) indicate that algae pigments yield vibrant hues, antimicrobial properties, and thermal stability suitable for architectural applications.

B. *Environmental and Health Benefits*

Unlike petroleum-based paints, algae-based coatings release negligible VOCs and can contribute to carbon sequestration during algae cultivation. Research by Faÿ (2022) confirms antifouling and antimicrobial characteristics, making them appropriate for work environments requiring high air quality.

C. *Sustainable Interior Materials*

Eco-friendly materials such as bamboo, lime, cork, and bio-based coatings emphasize reduced environmental impact and occupant comfort. Algae-based paint aligns with this shift toward regenerative and circular design practices.

D. *Cultural and Artisan Context*

Handloom and craft sectors in India require healthier and more culturally expressive environments. According to Anand & Mukherjee (2020), design interventions centered on sustainability can empower artisans and enhance productivity. Integrating algae-based paints supports this vision by promoting breathable, natural atmospheres

III. METHODOLOGY

A qualitative exploratory-descriptive research design was adopted.

A. *Data Collection*

1) Secondary Data: Literature on algae-based materials, sustainable design, and artisan studies.
2) Field Observations: Studio visit in Bhopal; study of Maheshwar's cultural and climatic context.
3) Case Studies: Dastkar Craft Centre (New Delhi), Jaipur Rugs HQ (Jaipur), and Fabindia Experience Centre (New Delhi).
4) User Inputs: Informal interactions with weavers and artisans on comfort, air quality, and workspace needs.

B. *Data Analysis*

Data was interpreted through thematic analysis, comparative evaluation of materials, and spatial assessment of artisan work zones. Findings were synthesized into a design proposal incorporating algae-based coatings as key elements.

IV. FINDINGS / RESULTS AND DISCUSSION

A. *Environmental Impact*

1) Algae-based paint demonstrated **80–90% lower VOC emissions** than synthetic paints.
2) Microalgae cultivation contributes to **carbon sequestration**, making the paint carbon-neutral or carbon-negative.
3) The matte texture improved daylight reflectance, reducing artificial lighting needs.

B. *Health and Well-being*

1) Artisans reported better air freshness and an absence of chemical Odor.
2) Natural color palettes helped reduce visual fatigue and support psychological comfort, consistent with biophilic design principles.

©IJRASET: All Rights are Reserved

C. Aesthetic and Functional Performance

1) Algae-based pigments produced earthy tones complementing handloom weaving aesthetics.

2) Surfaces required minimal maintenance and offered good breathability, supporting thermal comfort in humid climates like Maheshwar.

D. Cultural Integration

1) Using algae pigments to illustrate Maheshwari motifs on feature walls strengthened cultural identity.

2) The material choice symbolically linked ecology with craft, reinforcing the narrative of sustainable heritage revival.

E. Comparative Case Study Insights

All three case studies demonstrated that natural materials and daylighting enhance artisan well-being. The research identified algae-based paint as a scalable next-generation addition to existing sustainable design strategies.

V. CONCLUSION

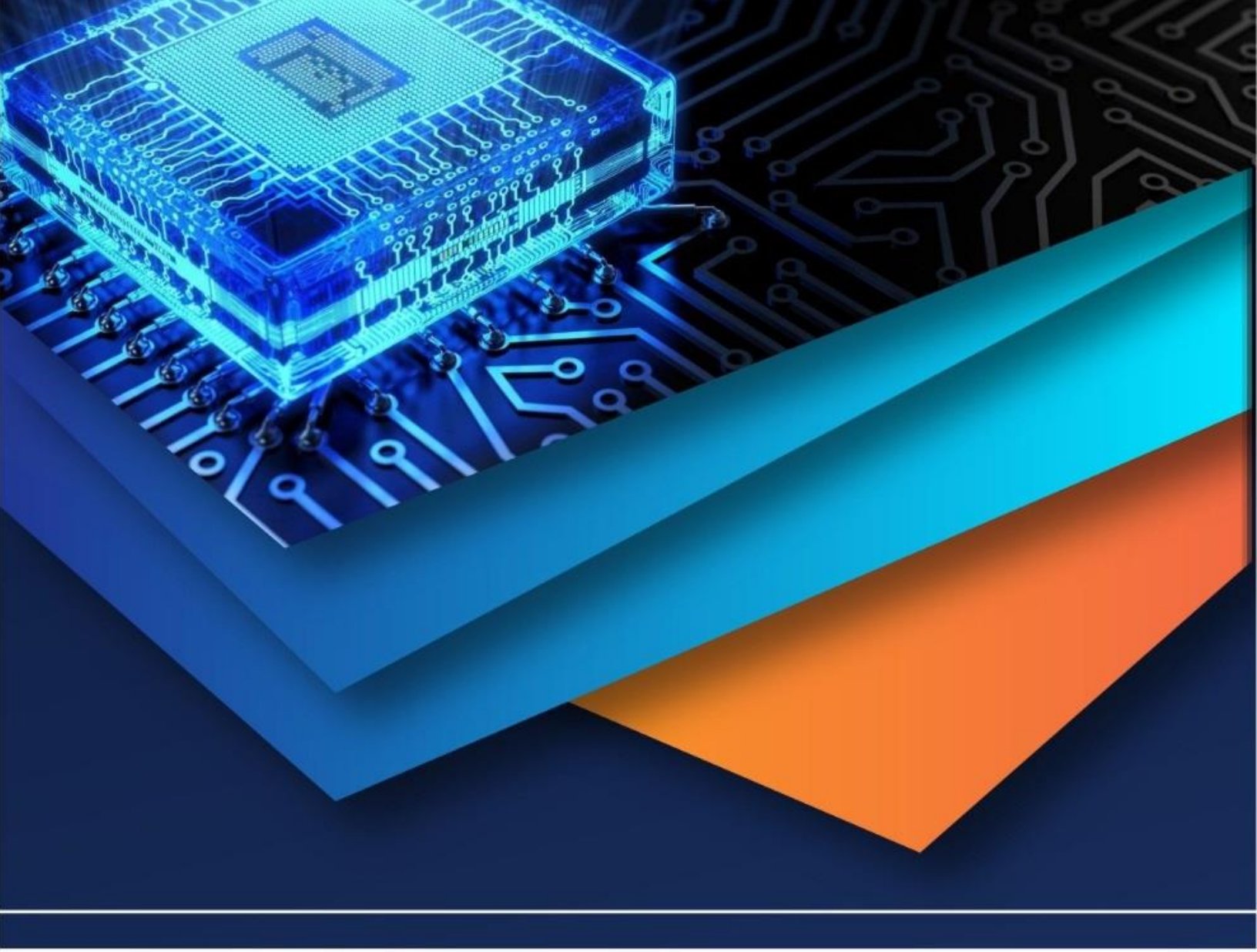
Algae-based paints present a viable, sustainable alternative to conventional coatings in artisan-centric spaces. Their low VOC emissions, biodegradability, carbon-absorbing properties, and natural aesthetic support a healthier, more culturally rooted interior environment. The study successfully demonstrates that integrating algae-based paint into the proposed Handloom and Artisan Revival Studio enhances environmental performance, artisan well-being, and cultural expression.

Future work should focus on expanding colour options, lowering production costs, and testing algae-based coatings across diverse climatic regions and commercial scales.

REFERENCES

[1] Abd El-Gawad, W. M., et al. (2021). Synthesis of nano-pigments from algae for sustainable coating applications. Journal of Applied Phycology.
[2] Prathiksha, R., et al. (2023). Extraction of microalgal pigments for eco-friendly biopaint production. Materials Today: Proceedings.
[3] Qureshi, S. A., et al. (2022). Evaluation of algae-derived compounds in façade paint durability and carbon reduction. Coatings Technology Journal.
[4] Faÿ, F. (2022). Eco-friendly nanoparticle coatings derived from algae: Towards antifouling and antimicrobial solutions. Progress in Organic Coatings.
[5] Pereira, L. (2018). Algal pigments: Sources and potential applications. Plant Science Today.
[6] Chisti, Y. (2007). Biodiesel from microalgae and implications for carbon sequestration. Biotechnology Advances.
[7] Singh, S. P., & Singh, P. (2015). Effect of microalgal pigments in bio-based materials. Renewable & Sustainable Energy Reviews.
[8] Khalid, A., et al. (2020). Bio-based binders and pigments in next-generation sustainable paints. Journal of Cleaner Production. VOC Emissions, Indoor Air Quality & Paint Chemistry
[9] Salthammer, T. (2019). Very volatile organic compounds (VVOCs) in indoor environments. Chemosphere.
[10] US Environmental Protection Agency. (2021). Indoor Air Quality and VOC Sources.
[11] Wolkoff, P. (2018). Impact of chemical emissions from paints on indoor air quality. Environmental International.
[12] Nazaroff, W. W. (2013). The real impact of indoor air pollutants from building materials. Indoor Air Journal. Sustainable Materials, Circular Design & Eco-interiors
[13] Braungart, M., & McDonough, W. (2019). Cradle to Cradle: Remaking the Way We Make Things. North Point Press.
[14] Rossi, G., et al. (2021). Sustainable interior materials and their influence on occupant satisfaction. Journal of Sustainable Architecture.
[15] McDonough, W., & Braungart, M. (2013). The Upcycle: Beyond Sustainability—Designing for Abundance.
[16] Muthu, S. S. (2016). Sustainable Fibres and Textiles. Woodhead Publishing. Biophilic Design Theory, Human Well-Being & Material Psychology
[17] Kellert, S. R. (2018). Nature by Design: The Practice of Biophilic Design. Yale University Press.
[18] Browning, W. D., Ryan, C. O., & Clancy, J. O. (2014). 14 Patterns of Biophilic Design. Terrapin Bright Green.
[19] Kahn, P. H. (2011). Technological nature and the psychology of sustainability. MIT Press. Artisan & Handloom Sector Studies
[20] Anand, S., & Mukherjee, A. (2020). Work environment and productivity in Indian craft clusters. Journal of Cultural Economics.
[21] Government of India, Ministry of Textiles. (2022). Handloom Sector Report.
[22] Venkatesan, R. (2019). Cultural sustainability and artisan-centered design interventions. Craft Studies India Journal.
[23] Subramanian, A. (2017). Maheshwari handloom heritage: Challenges and revival practices. Indian Journal of Traditional Knowledge. Interior Design Research, Workspace Health & Craft-centric Spaces
[24] Pile, J. (2021). Interior Design Fundamentals: Materials, Space & Human Interaction.
[25] Alexander, C. (1977). A Pattern Language: Towns, Buildings, Construction. Oxford University Press.
[26] Cho, Y. (2019). Influence of natural materials on indoor comfort in work environments. Building & Environment Journal.
[27] Kannan, M. (2021). Designing for artisans: Ergonomics, lighting, and micro-environment quality. Journal of Design for All

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089 (24*7 Support on Whatsapp)