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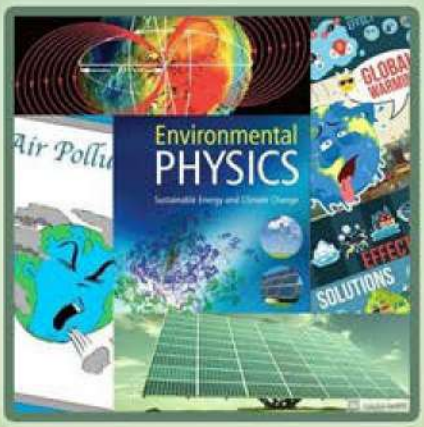

IV International Conference on Physical Aspects of Environment

ICPAE 2025

PROCEEDINGS

Zrenjanin, Serbia, August 29-30, 2025.

University of Novi Sad
Technical Faculty
"Mihajlo Pupin"
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IV International Conference on Physical Aspects of Environment ICPAE2025

Proceedings

Zrenjanin, 29 – 30th, August 2025.

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Milan Nikolić, Ph.D, Professor
Dean of the Technical Faculty “Mihajlo Pupin” Zrenjanin, University of Novi Sad, Serbia

Editor:
Darko Radovančević, Ph.D, Assistant Professor
Technical Faculty “Mihajlo Pupin” Zrenjanin, University of Novi Sad, Serbia

Co-Editor:
Ljubiša Nešić, Ph.D, Professor
Faculty of Sciences and Mathematics, University of Niš, Serbia

Technical preparation:
Luka Đorđević, M.Sc, Assistant
Technical Faculty “Mihajlo Pupin” Zrenjanin, University of Novi Sad, Serbia

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INTRODUCTION

IV International Conference on Physical Aspects of Environment (ICPAE2025), held on August 29–30, 2025, was organised by the Technical Faculty "Mihajlo Pupin" Zrenjanin. The Conference co-organiser was the Faculty of Sciences and Mathematics, University of Niš.

The members of Conference committees were distinguished professors and researchers from the University of Novi Sad, the University of Niš, the University of Pristina with temporary headquarters in Kosovska Mitrovica, the Institute of Physics in Zemun, the University of Maribor, the University of Josip Juraj Štrosmajer in Osijek, the University of Rijeka, the University of Montenegro, the "Ss. Cyril and Methodius" University in Skopje, the University of Banja Luka, the University of Sarajevo, the West University of Timișoara, Amirkabir University of Technology (Tehran, Iran), Donghua University (Shanghai, China), and Wuhan Textile University (Wuhan, China).

The paper presentations at the Conference were moderated by Vasilije Petrović, Ph.D, Professor; Ljubiša Nešić, Ph.D, Professor; Jasna Tolmač, Ph.D, Assistant Professor; Darko Radovančević, Ph.D, Assistant Professor.

The Conference included 42 submitted papers, of which 5 were presented as plenary lectures, and the remaining were allocated to brief oral sessions. Among the submissions, 14 papers had first authors from China, Iran, Sweden, Romania, Bulgaria, North Macedonia, Montenegro, Bosnia and Herzegovina, Croatia, Slovenia, and Ethiopia, and 28 papers had first authors from Serbia. One paper had a co-author from the United Kingdom.

The Conference gathered distinguished participants who presented their research, ideas, and accomplishments on a range of pressing topics, including geophysics, environmental modelling, air pollution, the greenhouse effect, global warming and climate change, radiation and the environment, energy efficiency and sustainable development, environmental physics and education, as well as industry and new materials.

President of the Organizing Committee

Darko Radovančević, Ph.D, Assistant Professor

Zrenjanin, 29 - 30th August 2025.

Conference participants are from the following countries:

United Kingdom

Bosnia and Herzegovina

Romania

North Macedonia

Serbia

Croatia

Iran

Bulgaria

Ethiopia

Montenegro

China

Slovenia

Sweden

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LECTURES

Conference Proceedings
ICPAE 2025, August 29–30, Zrenjanin, Serbia
Technical Faculty "Mihajlo Pupin", Zrenjanin & Faculty of Sciences and Mathematics, Niš

Changing the Planet Earth Through Sustainable Materials

Anita Milosavljević[1], Vasilije Petrović[1], Dragan Đorđić[2], Darko Radovančević[1]
Marija Petrović[1], Sonja Jordeva[3]

[1]*University of Novi Sad, Technical faculty "Mihajlo Pupin" Zrenjanin, Đure Đakovića BB, Zrenjanin, Serbia*
[2]*Institute of General and Psysical Chemistry, Studentski trg 12/V, Belgrade, Srbija*
[3]*University Goce Delcev Stip, Faculty of Technology, Republic of North Macedonia*
anita.milosavljevic@uns.ac.rs

Abstract. Sustainable materials are designed with the aim of reducing the use of non-renewable resources, promoting recycling, and enabling biodegradability, which makes them particularly relevant to both the academic community and the industrial sector. Research in this field is of essential importance for accelerating the transition toward a circular economy and significantly reducing the negative impacts on the environment. This paper provides an analysis of contemporary scientific literature, identifying the current state and projected trends within categories of materials related to sustainability: sustainable materials, green materials, biomaterials, environmentally friendly materials, alternative materials, recycled materials, as well as material recovery from complex products.

Keywords: sustainable materials, recyclable materials, green materials, biodegradable materials, eco-friendly materials

INTRODUCTION

Sustainable materials play a pivotal role in the transition toward a more environmentally responsible society by contributing to environmental protection, the conservation of natural resources, and the improvement of overall quality of life. Their application across various industries such as construction, automotive, fashion, food, electronics, and packaging reflects a growing awareness of the need to reduce negative environmental impacts. Although there is no unified framework for evaluating sustainable materials, current practices indicate significant progress in their development and application.

This paper analyzes research areas relevant to the assessment of sustainable materials, including environmental impact, performance and durability, economic viability, health and safety, social sustainability, as well as implementation and practical use.

In addition to sustainable, recyclable, green, biodegradable, and environmentally friendly materials, particular emphasis is placed on the development of advanced materials through nanotechnology, 3D printing, and sustainable composites. The paper offers a comprehensive overview of seven key categories of materials associated with sustainability from green and bio-based materials to recycled and alternative solutions. Based on the analysis, it can be concluded that sustainable development requires an approach that extends

product lifespan, improves production efficiency, and enhances recycling and reuse strategies.

Green Composite Materials

Natural fibers and resins, as well as various fiber-reinforcement methods, represent alternative solutions to synthetic fibers, given their lower cost, biodegradability, and widespread availability. The use of these materials enables the effective replacement of synthetic polymer composites. These materials may be defined as polymer-based materials that incorporate natural fibers such as bamboo, coconut fibers, flax, and hemp. Natural fibers are typically classified into three categories: animal-based fibers (e.g., silk and wool), plant-based fibers (e.g., seed, fruit, and leaf fibers), and mineral-based fibers, such as asbestos. These biocomposites can be applied in industries such as electronics, furniture manufacturing, and sports equipment.

Green composites, also known as environmentally friendly materials, are emerging as a promising area of research due to their renewable, recyclable, and biodegradable nature. They can be produced in various forms, including polymer-based composites reinforced with natural fibers such as hemp or flax, as well as cement-based composites utilizing novel binders like geopolymers and recycled aggregates. The mechanical properties of green composites particularly those reinforced with bamboo fibers indicate their potential for application across diverse industrial sectors.

The integration of biodegradable polymers derived from natural resources further enhances the environmental sustainability of green composites. Although these materials demonstrate considerable potential, it is essential to carefully align their use with the specific requirements of individual industries.

Green composites composed of natural fibers and biodegradable polymers have shown significant promise in industries such as automotive manufacturing and construction. Research in this field highlights the ecological benefits of using fibers such as bamboo, flax, and hemp, primarily due to their recyclability and reduced reliance on synthetic materials.

Biomaterials and Bioinspired Materials – Their Applications and Research Directions

Biomaterials and bioinspired materials, often developed based on biological systems and processes, are increasingly attracting the attention of both researchers and industry due to their wide range of applications, sustainability, and potential for innovation.

A significant number of studies indicate that biomaterials, characterized by high biocompatibility and low toxicity, are utilized in the production of medical devices, food packaging, and drug delivery systems. In this context, bioinspired nanomaterials are particularly notable for their ability to enable controlled release of active substances while maintaining biodegradability.

Furthermore, various research efforts highlight a growing interest in bio-based nanostructures that mimic natural resilience and flexibility, offering enhanced performance in biomedical applications. This innovation in the field of nano-biomaterials opens new pathways for applications in regenerative medicine, bioengineering, and the development of functional bio-devices.

Particularly noteworthy are biomimetic materials, which are inspired by natural structures and functions. The increasing demand for bio-based alternatives clearly indicates that biomaterials will play a key role in the future development of sustainable and functional solutions in medicine and various industrial sectors.

Environmentally Friendly and Recycled Materials – Their Role in Sustainable Development and Advanced Industries

These materials have traditionally been predominantly applied in the textile industry, furniture manufacturing, as well as in construction and decorative applications, significantly contributing to the reduction of environmental impact.

Recycled materials further enhance sustainability by enabling the reduction of the exploitation of non-renewable resources, emissions of harmful substances into the environment, water consumption, and the volume of waste disposed of in landfills. The most commonly recycled textile materials include cotton and its composites with polyester, which can be processed using chemical, biochemical, or mechanical methods. However, certain materials, such as recycled paper, require additional control measures due to the presence of chemicals that may affect safety.

Despite the clear advantages, the recycling process continues to face a range of technical and social challenges.

Figure 1. A schematic representation of the circular recycling flow
(source: https://www.stylesocietymarketplace.com/pages/sustainability)

Alternative Materials - Future Trends and Sustainable Material Development

The use of alternative materials represents a growing trend across numerous industries, with an increasing emphasis on environmental sustainability and innovation. These materials include recycled raw materials, biodegradable composites, natural resources, and geopolymers, which are increasingly applied in fields such as construction, packaging manufacturing, design, the textile industry, and tool production.

Particular importance is attributed to the development of advanced recycling methods for cotton and polyester composites, including chemical, biochemical, and mechanical processes that enable the reuse of textile waste to reduce environmental impact. In construction, there is growing research into the use of natural materials such as wood, hemp, and cellulose, which are utilized in modern energy- efficient buildings.

In the context of packaging, there is a growing use of biodegradable biopolymers, addressing the issue of conventional plastic waste. The integration of recycled materials into standard construction components highlights the potential for improving environmental sustainability in infrastructure.

Innovations are manifested through the development of lightweight, waterproof, and high-strength materials obtained by processing plastic and rubber waste in combination with mineral fillers, opening new prospects for their application in the construction industry. Simultaneously, there is an increasing use of recycled materials in art and interior design, particularly in the production of furniture and decorative household elements. Strategies promoting the circular economy and energy conservation through innovative recycling approaches represent a key aspect of contemporary efforts to mitigate negative environmental impacts.

Research in furniture design and educational materials also indicates an expanding use of alternative materials, including paper, cardboard, glass, metal, and natural fiber composites.

The circular economy and material development emphasize the importance of coordinated efforts in the development and commercialization of sustainable materials. The focus lies on resource redistribution through recycling and reuse, as well as waste reduction throughout all stages of the product life cycle.

Polymer composites reinforced with natural fibers are lightweight, biodegradable, mechanically reliable materials suitable for engineering applications. Challenges include variable fiber quality, thermal stability, and water absorption capacity. Advanced solutions involve hybridization with synthetic fibers, chemical treatments, and the development of numerical models to simulate performance.

Figure 2. Biodegradable materials
(source: https://maidsbytrade.com/portland-recycling/)

The analysis of additive manufacturing in the context of sustainability highlights its ability to produce complex geometries while reducing waste. Potential applications span across aerospace, robotics, and medicine. Additionally, this includes the procurement of sustainable materials, product circularity and recycling, as well as the development of biodegradable and biologically derived polymers.

Sustainable applied materials offer solutions to multiple challenges faced by contemporary society, from waste reduction and resource conservation to the creation of materials with advanced functional properties. Their integration in the early stages of design, combined with circular economy strategies and advanced technologies (such as 3D

printing and smart composites), forms the foundation for achieving a sustainable and innovative future.

CONCLUSION

The research on sustainable materials discussed in this study highlights their increasing importance in the context of environmental responsibility, economic efficiency, and technological advancement. These materials, derived from renewable or recycled sources, contribute to reducing the negative environmental impact through lower emissions of harmful substances, preservation of natural resources, and recyclability.

The analysis of available literature has enabled the identification of key topics, challenges, and directions for further development, with particular emphasis on the need for lifecycle integration, economic assessments, and interdisciplinary collaboration. The future development of sustainable materials in fields such as composites, the textile industry, nanotechnology, and biodegradable polymers represents a crucial component in the transition towards a more sustainable society, a healthier environment, and a circular economy.

REFERENCES

1. Petrović, V., Stepanović, J., Stamenković, M., Skoko, I., & Stefanović, S. (2011). ”Life cycle and recycling of textiles”, Tekstilna Industrija, 59(3), 34–39.
2. D. Radivojević, M. Đorđević, D. Trajković, Textile testing, High School of Textile, Leskovac, Investigation of the influence of qualitative characteristics of fabrics on thermophysiological properties of clothes - doctoral dissertation – Mirjana Reljić – Leskovac 2016.
3. Zhang, Y.; Song, Y. Tax rebates, technological innovation and sustainable development: Evidence from Chinese micro-level data. Technol. Forecast. Soc. Chang. 2022, 176, 121481.
4. Park, E.; Kwon, S.J. What motivations drive sustainable energy-saving behavior?: An examination in South Korea. Renew. Sustain. Energy Rev. 2017, 79, 494–502.
5. Sato, F.E.K.; Nakata, T. Recoverability Analysis of Critical Materials from Electric Vehicle Lithium-Ion Batteries through a Dynamic Fleet-Based Approach for Japan. Sustainability 2019, 12, 147.
6. Bobba. S.; Bianco, I.; Eynard, U.; Carrara, S.; Mathieux, F.; Blengini, G.A. Bridging Tools to Better Understand Environmental Performances and Raw Materials Supply of Traction Batteries in the Future EU Fleet. Energies 2020, 13, 2513.
7. Jacometti, V. Circular Economy and Waste in the Fashion Industry. Laws 2019, 8, 27.
8. D.Itria. E.; Aus, R. Circular fashion: Evolving practices in a changing industry. Sustain. Sci. Pract. Policy 2023, 19, 2220592.
9. Suarez-Visbal, L.J.; Carreón, J.R.; Corona, B.; Worrell, E. The Social Impacts of Circular Strategies in the Apparel Value Chain; A Comparative Study Between Three Countries. Circ. Econ. Sustain. 2023, 3, 757–790.
10. Meherishi, L.; Narayana, S.A.; Ranjani, K.S. Sustainable packaging for supply chain management in the circular economy: A review. J. Clean. Prod. 2019, 237, 117582.

[CrossRef] Coelho, P.M.; Corona, B.; Ten Klooster, R.; Worrell, E. Sustainability of reusable packaging - Current situation and trends. Resour. Conserv. Recycl. X 2020, 6, 100037.