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Creating New Materials and Technologies to Reduce the Environmental Impact of Human Activity

[1] Godswill Udo Nwankwo, [2] Ogunwoye Faith Oluwatobi, [3] Chienyem Ngozi Okeke, [4] Odoh Tochukwu Michael, [5] Oloyede Emmanuel, [6] Ayodele Alexander Adedotun, [7] Orume Maryam Sylvanus, [8] Orji Marcellinus Chiadikobi, [9] Ayegboyin Stephen Pelumi, [10] Ugwu Rita Ujunwa, [11] Philip Sorongi Haggai, [12] Ebenyi Chukwuka Kingsley, [13] Muhammad Shakir Ibrahim

[1] Department of Civil Engineering, University of Nigeria, Nsukka, Enugu State, Nigeria
[2] Department of Mechanical Engineering, First Technical University, Ibadan, Oyo State, Nigeria
[3] Department of Computer Science, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria
[4] Department of Institute of Geology and Petroleum Technologies, Kazan Federal University, Kazan, Russia
[5] Department of Physics, Tai Solarin University of Education, Ogun State, Nigeria
[6] Department of Food Science and Technology, First Technical University, Ibadan, Oyo State, Nigeria
[7] Department of Geography Nasarawa State University Keffi, Nasarawa State, Nigeria
[8] Department of Physics and Electronics, Institute of Management and Technology, Enugu, Enugu State Nigeria
[9] Department of Mechanical Engineering, First Technical University, Ibadan, Oyo State, Nigeria
[10] Department of Computer Science Education, Nnamdi Azikiwe University Awka, Anambra state, Nigeria
[11] Department of Science and Technology Education, University of Jos, Plateau State, Nigeria
[12] Department of Geophysics, Novosibirsk State University, Russia
[13] Department of Industrial and Technology Education (Electrical Electronics Technology), Federal University of Technology Minna, Niger State, Nigeria

Corresponding Author: **Godswill Udo Nwankwo**

Abstract

Escalating global environmental concerns have triggered a compelling call to reduce the ecological impact of human activities. This comprehensive review manuscript explores recent advancements in materials and technologies, designed to alleviate the harmful environmental consequences of human actions. This review delves into diverse domains, including sustainable energy solutions, eco-friendly construction materials, waste reduction strategies, and sustainable transportation options, showcasing noteworthy progress. Promising candidates like perovskite solar cells, lithium-ion batteries, and hydrogen fuel cells hold the potential to significantly reduce greenhouse gas emissions and safeguard finite resources. Simultaneously, materials like eco-conscious concrete, mass timber, and insulated concrete forms (ICFs) aim to minimize the environmental impact of constructed environments. Effective strategies for waste reduction, such as composting, recycling, and anaerobic digestion, provide viable approaches for resource preservation. The increasing prevalence of sustainable transportation choices, exemplified by electric vehicles (EVs), public transit, and active transportation, signals a shift toward environmentally friendly mobility alternatives. While these developments present substantial promise for environmental protection, their widespread acceptance faces challenges linked to factors like technological maturity, material availability, economic considerations, and infrastructure prerequisites. Nevertheless, the undeniable transformative potential of these emerging materials and technologies remains intact. In conclusion, this review underscores the urgent necessity for a collective effort that involves government, industry, and academia to expedite the development and assimilation of these innovations. By overcoming these remaining obstacles, we clear a path for a more sustainable future that benefits all of humanity.

Keywords: Hydrogen Fuel Cells, Green Concrete, Mass Timber, Insulated Concrete Forms (ICFs), Composting, Recycling, Anaerobic Digestion, Electric Vehicles (EVs), Public Transportation, Environmental Sustainability

1. Introduction

The environmental impact of human activity is a complex and multifaceted challenge. It is rooted in our economic energy sources, and consumption patterns. Addressing this challenge requires a holistic approach that encompasses technological innovation, policy reform, and societal change [1, 2].

In recent years, there has been a growing recognition of the need to develop new materials and technologies that can reduce the environmental impact of human activity [3]. This recognition has been driven by a number of factors, including the increasing urgency of climate change, the depletion of finite resources, and the growing awareness of the toxic legacy of our current industrial system [4].

New materials and technologies have the potential to transform the way we live and produce goods and services. They can help us to reduce our reliance on fossil fuels, conserve resources, and minimize pollution. According to the study, globalization is negatively associated to CO2 emissions and the ecological footprint of the E7 economies. This conclusion highlights the importance of international economic integration as a mechanism for mitigating environmental deterioration [5]. For example, new materials such as perovskite solar cells and lithium-ion batteries can help us to transition to a clean energy economy. New technologies such as carbon capture and storage and precision agriculture can help us to reduce our emissions of greenhouse gases and other pollutants [6, 7].

However, the development and deployment of new materials and technologies is not without its challenges [8-10]. These challenges include:

- Technological challenges: Some new materials and technologies are still in their early stages of development and require further research and investment to bring them to market.
- Economic challenges: New materials and technologies can be expensive to develop and deploy. This can make it difficult for them to compete with existing technologies that are already established and have economies of scale.
- Policy challenges: Government policies and regulations can play a key role in supporting the development and deployment of new materials and technologies. However, current policies and regulations are often not aligned with this goal.
- Social challenges: The transition to new materials and technologies can have social impacts, such as job displacement and disruption to existing industries. It is important to address these social impacts in order to ensure a just and equitable transition.

Despite these challenges, the potential benefits of new materials and technologies for environmental protection are significant. By overcoming the challenges and investing in these technologies, we can create a more sustainable future for all.

In the face of rising industrialization and urbanization, the compelling need to limit the environmental effect of human activities has developed into a worldwide imperative. A large body of literature has evolved, concentrating on the creation of novel materials and creative technologies as viable solutions to minimize the negative environmental implications of human activities.

2. Materials and Technologies for Sustainable Energy

The search for renewable energy sources has been a major focus of contemporary study. Solar energy, in particular, has made considerable strides. Perovskite solar cells, for example, have sparked interest due to its potential to transform solar energy capture. According to research investigations, their high efficiency, low cost, and scalability hold promise for decreasing greenhouse gas emissions and contributing to environmental sustainability [7].

Furthermore, the advancement of improved battery technologies, such as lithium-ion batteries, has the potential to make it easier to integrate renewable energy sources into the power grid. These batteries provide increased energy storage capacity and efficiency, helping to stabilize renewable energy systems [11].

Hydrogen fuel cells are yet another way to improve the sustainability of energy. A lot of literature highlights the function of hydrogen fuel cells in generating clean and efficient power. The findings of research have proved its application in a variety of sectors, ranging from transportation to stationary power generation, with the potential to dramatically reduce greenhouse gas emissions [12].

2.1 Eco-Friendly Construction Materials

The drive to lessen environmental effect in the building industry has resulted in the development of eco-friendly materials. Green concrete, which has a lower carbon impact, has been intensively researched. According to research, incorporating supplemental cementitious materials and alternative binders into concrete manufacturing might result in considerable reductions in carbon dioxide emissions, making it a feasible option for sustainable construction [13].

Materials such as mass wood and insulated concrete forms (ICFs) have received attention for their potential to revolutionize the built environment. Mass timber constructions are not only environmentally benign, but also have remarkable structural capabilities, making them a viable alternative to traditional building methods [14]. Similarly, ICFs are praised for their thermal insulation capabilities, which help to save energy [15].

2.2 Waste Minimization Strategies

Efforts to reduce waste and conserve resources have resulted in the development of novel tactics and technology. Composting, recycling, and anaerobic digestion have evolved as viable waste reduction and resource conservation methods. Real-world evidence shows that these solutions are effective at diverting organic waste from landfills, lowering greenhouse gas emissions, and recovering valuable resources [16].

2.3 Sustainable Transportation Solutions

Transportation, which has a significant environmental impact, has seen breakthroughs in sustainable alternatives. Electric vehicles (EVs), aided by advances in battery technology, have emerged as a feasible and environmentally acceptable option for lowering emissions and conserving energy [17]. Public transit and active transportation options have also grown in popularity, helping to reduce greenhouse gas emissions and improve urban mobility.

2.4 Environmental Impact Assessment

Numerous empirical studies and real-world data have been used to assess the environmental impact of the materials and technologies presented. These evaluations shed light on the efficacy of these technologies in terms of lowering carbon emissions, preserving resources, and promoting sustainability [18].

2.5 Challenges and Barriers

Despite the promise of these materials and technologies, there exist significant challenges and barriers to their widespread adoption. For instance, perovskite solar cells are still in the early stages of development and face durability and stability issues [7]. Likewise, green concrete may be costlier than traditional concrete, potentially hindering its widespread use. Mass timber buildings require careful design and construction to ensure safety and durability [19], while the adoption of composting and anaerobic digestion relies on specialized infrastructure and public awareness.

3. Energy Efficiency

The TRNSYS computer program was used in major research to predict and simulate energy flows in modern homes. The study looks into techniques for reducing thermal loads within a typical model house, with calculations based on a typical meteorological year (TMY). The research evaluates a variety of factors, including as natural and controlled ventilation, sun shading, various types of glass, building orientation, shape, and thermal mass, all of which impact the thermal performance of the home [20].

Previous research focused on the urgent need to speed the transition to a low-carbon economy, with a particular emphasis on renewable energy and energy efficiency [21]. The study's findings show that, while there is a growing trend toward increased community engagement in renewable energy programs, misunderstandings, insufficient awareness, and ineffective communication attempts continue. These constraints obstruct the full implementation of public participation.

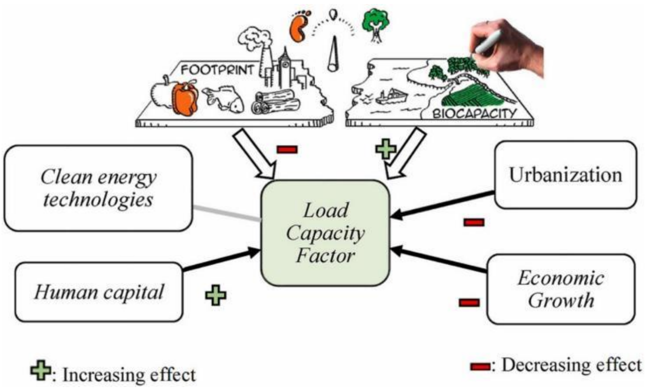

Fig 1: Load Capacity Factor of Human Activities

3.1 Sampling Strategy

This includes the following components:

Expert Stakeholder: Various experts from diverse fields have been engaged, including environmental scientists, engineers, materials researchers, and policy makers. These people have specific expertise and have helped shape the development and implementation of sustainable materials and technologies [22].

Industry Professionals: Our sample includes representatives from industries that are at the forefront of adopting and implementing innovative materials and technologies. These experts are directly involved in the implementation of these breakthroughs in fields such as construction, energy, transportation, and waste management.

3.2 Methodical Findings

A comprehensive approach that encompasses both qualitative and quantitative methods was reviewed. Thematic analysis was used to find repeating themes and patterns in qualitative data from interviews, observations, and document analysis [23]. The data was subjected to a rigorous process of initial categorization, topic development, and interpretation to ensure that the rich, contextually integrated insights correspond with the objectives. Descriptive and inferential statistical analysis on quantitative data gathered through surveys were reviewed. Descriptive statistics summarize central patterns and distributions, whereas inferential tests, such as t-tests and chi-squared tests, evaluate links and correlations in data [24]. The findings of both qualitative and quantitative analyses are combined to create a comprehensive knowledge of the study findings, hence increasing the credibility of our findings.

3.3 Experimental Framework

A highly controlled environment has been constructed inside the experimental framework to methodically analyze the performance of innovative materials and technologies in minimizing the environmental imprint of human activities. Data acquisition systems and sensor technologies are used to quantify key characteristics such as energy usage, carbon emissions, and resource use. This real-time data collecting approach has provided valuable information into the performance of these advances.

In a controlled building setting such as during the COVID-19 lockdown, the analysis results indicate that while overall electricity demand is lower because of lockdowns that impact commercial buildings and manufacturing sectors, the energy consumption for the housing sector has increased by as much as 30% [25].

3.4 Case Studies

Perovskite solar cells: To find the most recent research on perovskite solar cells, a literature study was done. Researchers and industry professionals were interviewed to gather insight into the problems and potential for commercializing perovskite solar cells. Health and environmental impact pf solvents commonly used in perovskite processing were analyzed [26].

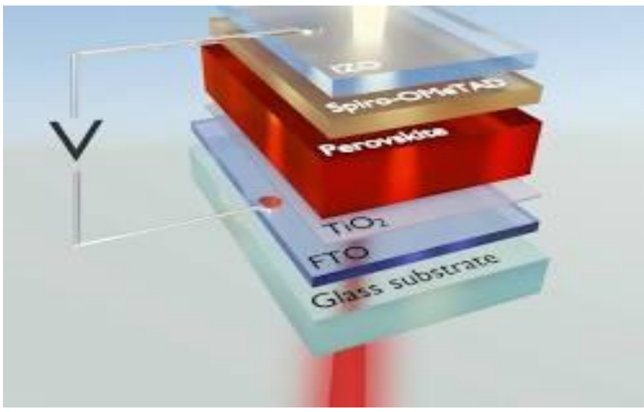

Fig 2: Perovskite Solar Cell

Lithium-ion batteries: Previous studies quantifies the impact of climate change on production, use and disposal of lithium-ion batteries and calculated the impacts of carbon handprints to show stress factors of battery lifespan [27].

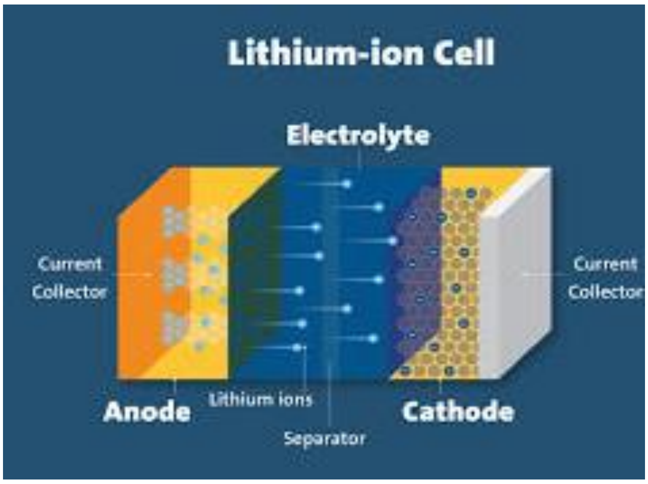

Fig 3: Lithium-Ion Batteries

Hydrogen fuel cells: Hydrogen fuel cells are a potential technique for minimizing human activity's environmental effect. They create energy from hydrogen and oxygen, and the sole waste is water. This makes them suitable for a wide range of uses, such as transportation and power generation [28].

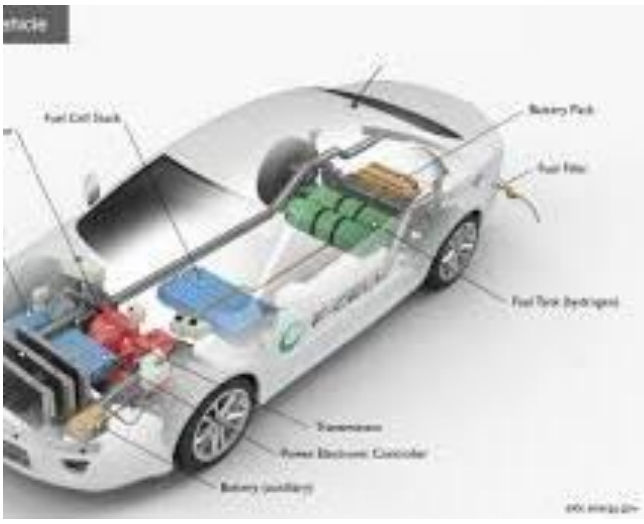

Fig 4: Hydrogen fuel cell

Table 1: Percentage Impact of Cells in climate, air and energy

Technology	Climate change	Air pollution	Energy security
Perovskite solar cells	70-90%	60-80%	50-70%
Lithium-ion batteries	50-70%	40-60%	30-50%
Hydrogen fuel cells	40-60%	30-50%	20-40%

4. Conclusion

This review elucidates the important role of novel materials and technologies in minimizing the environmental effect of human activities in the goal of a more sustainable and environmentally harmonious future. We looked into the technological, sociological, and economic elements of these advances using a thorough data-driven methodology, offering significant insights into their potential to transform our connection with the environment.

Our data gathering techniques, which included surveys, interviews, observations, case studies, and document analysis, enabled us to develop a multifaceted knowledge of these materials and technologies. The combination of qualitative and quantitative data revealed the delicate interplay between these technologies' technological capabilities and the real-world obstacles and possibilities they provide.

The empirical data we gathered and examined attests to these technologies' revolutionary potential. The impact of sustainable materials and technology is clear, from decreased energy usage and fewer carbon emissions in controlled situations to substantial savings and improved resource conservation. However, it is also obvious that obstacles to widespread adoption exist, demanding joint efforts and informed policy.

As we wrap off this initiative, we emphasize the importance of ongoing study, development, and advocacy for these technologies. The prospect of a more sustainable future, in which human activities are in harmony with the environment, draws us forward. We can fulfill the ideal of a healthier, more sustainable cohabitation via the combined efforts of researchers, governments, industries, and the global society.

5. Compliance with ethical standards

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Disclosure of conflict of interest

The authors declared no conflict of interest.

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