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# Comparative Study of Various Sustainable Biochars as an Ingredient in Cement Concrete to Reduce Cement Consumption and Probable Carbon Sequestration

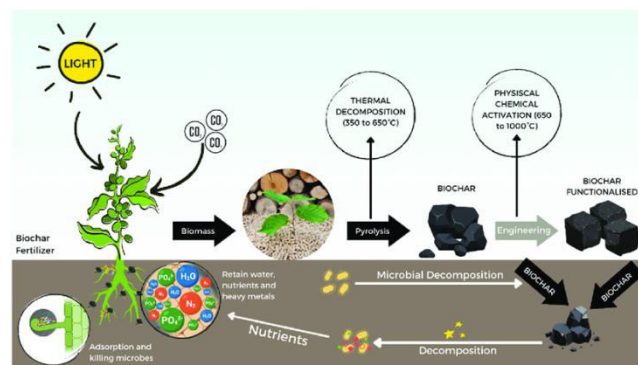
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**ABSTRACT:** The construction industry, in particular Portland cement production, is accountable for 8–10% of the global carbon dioxide (CO<sub>2</sub>) emissions. In order to address these environmental issues, this paper discusses the use of biochar, produced from agricultural wastes like coconut shells, cotton stalks, peanut shells, and rice husks, as a sustainable alternative to traditional cement in concrete. Produced by pyrolysis, biochar provides significant advantages, such as enhanced mechanical properties, improved durability, and significant carbon sequestration potential. The paper will focus on M20 grade concrete, commonly used in constructions, to investigate its performance and determine strategies that may reduce the environmental footprint. Results show potential in biochar-enhanced concrete in reducing dependence on cement while enhancing structural performance, thus pushing the agenda towards sustainable construction practices.



The pyrolysis process (agricultural residues → biochar)

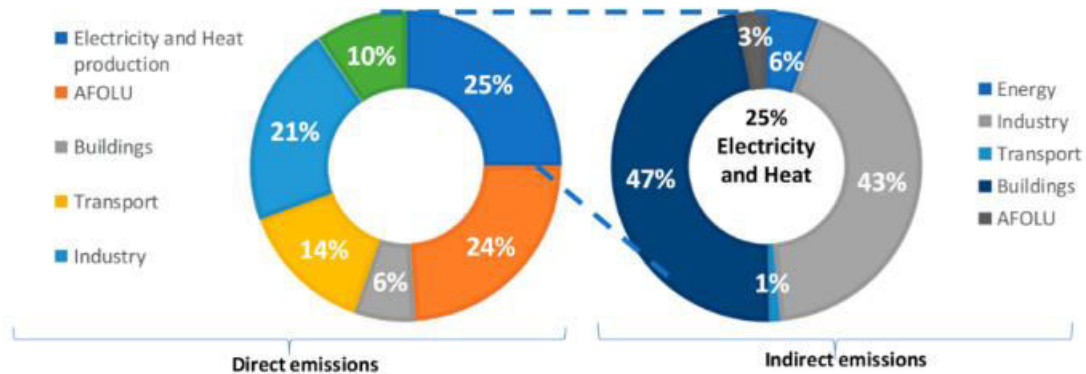
**KEYWORDS:** 1. Construction industry, 2. Portland cement production, 3. CO<sub>2</sub> emissions, 4. Sustainable alternatives, 5. Biochar, 6. Agricultural residues, 7. Coconut shells, 8. Cotton stalks, 9. Peanut shells, 10. Rice husks, 11. Pyrolysis, 12. Mechanical properties, 13. Durability, 14. Carbon sequestration, 15. M20 grade concrete, 16. Environmental footprint, 17. Cement dependency, 18. Structural performance, 19. Sustainable construction practice

## I. INTRODUCTION

Concrete plays an outstanding role in modern construction, but given its dependence on Portland cement, the method of production is typically energy-intensive and, as such, a major contributor to greenhouse gas emissions. This paper focuses on biochar, carbon-rich material byproduct from pyrolysis as a partial replacement for cement in concrete.

Rich in minerals such as silica (SiO<sub>2</sub>), calcium (CaO), and potassium (K), conversion of abundant low-cost agricultural residues like coconut shells, cotton stalks, peanut shells, and rice husks into biochar will enhance the properties of

concrete by making possible pozzolanic reactions that produce calcium silicate hydrate (C-S-H), a compound essential for concrete strength. In addition to enhancing the mechanical properties of concrete, significant carbon sequestration through this form of waste conversion addresses the environmental effect of construction.



"Portland Cement Carbon Footprint Visualization"

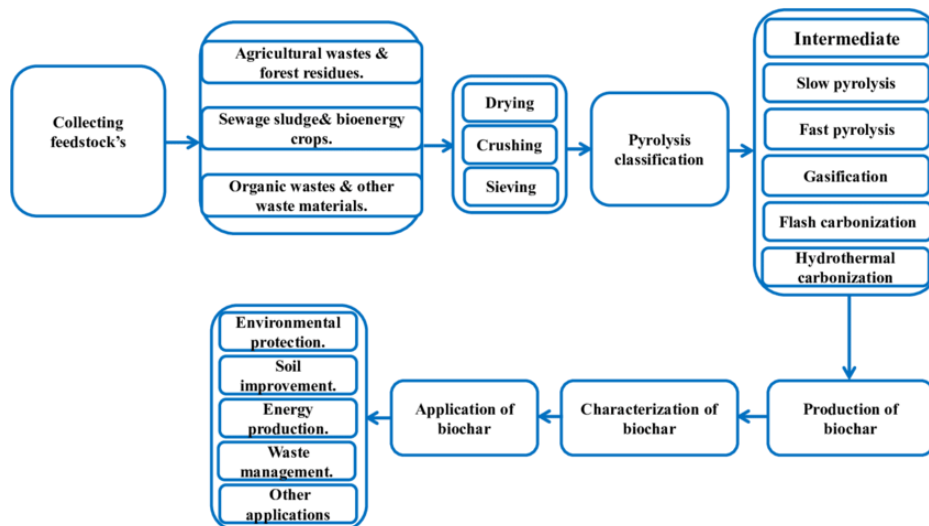
## II. METHODOLOGY

### 2.1 Biochar Production

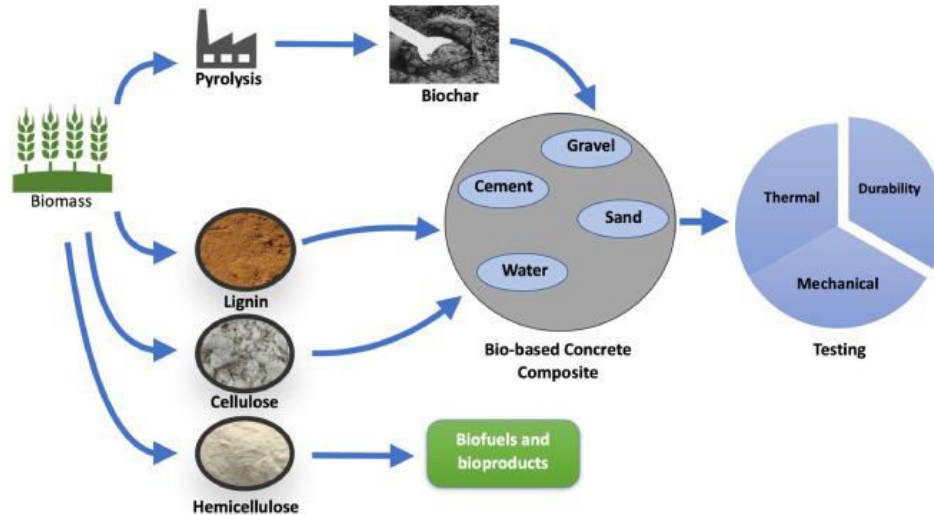
- Agricultural residues such as coconut shells, cotton stalks, peanut shells, and rice husks are subjected to pyrolysis at temperatures ranging from 400°C to 700°C.
- The resulting biochar is ground into a fine powder for uniform integration into cementitious materials.

### 2.2 Concrete Mix Design

- Biochar replaces 5%, 10%, 15%, and 20% of Portland cement by weight.
- M20 grade concrete is prepared with a mix ratio of 1:1.5:3 (cement: sand: coarse aggregate) and a water-cement ratio of 0.5.



"Biochar Production Process Flowchart"



"Concrete Mix Preparation Process visuals of biochar integration into M20 grade concrete. "

### 2.3 Testing and Analysis

- **Compressive Strength:** Tested at 7, 14, and 28 days.
- **Flexural Strength:** Measured through bending tests.
- **Durability:** Tested for water absorption, freeze-thaw, and acid resistance.
- **Workability:** Assessed via slump tests.
- **Carbon Sequestration:** Measured carbon stored in biochar-enhanced concrete.
- **Biochar Characterization:** Analyzed chemical composition using XRF, focusing on silica, calcium, and potassium.

## III. CASE STUDY ANALYSIS

### 3.1 Biochar-Enhanced Concrete

Rice Husk Biochar: Increases compressive strength and facilitates pozzolanic reactions.

Peanut Shell Biochar: Enhances durability and resistance to environmental conditions.

Coconut Shell Biochar: Improves flexural strength and reduces permeability.

Cotton Stalk Biochar: Provides long-term compressive strength and significant carbon sequestration.

Biochar Type	Compressive Strength	Flexural Strength	Durability	Carbon Sequestration
Control (100% Cement)	X MPa	A MPa	Standard	None
Rice Husk Biochar	Increases (X+5%)	A1 MPa	Improved	Moderate
Peanut Shell Biochar	Comparable (X+3%)	A2 MPa	Enhanced resistance	Low
Coconut Shell Biochar	X+4 MPa	Increases (A+10%)	Reduced permeability	Low
Cotton Stalk Biochar	Long-term increase (X+6%)	A3 MPa	Long-term durability	Significant

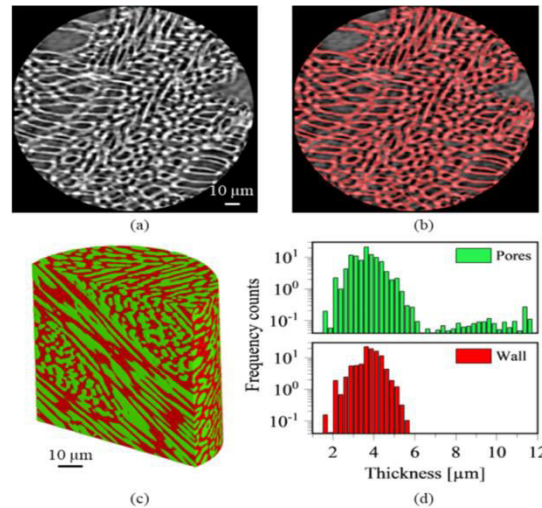
"Strength Comparison Chart"

### 3.2 M20 Grade Concrete

Standard mix used in residential and infrastructure projects.

Performance evaluated in terms of workability, strength, and durability.

Opportunities identified for reducing carbon emissions through biochar integration.



"Biochar-Enhanced Concrete Microstructure Analysis"

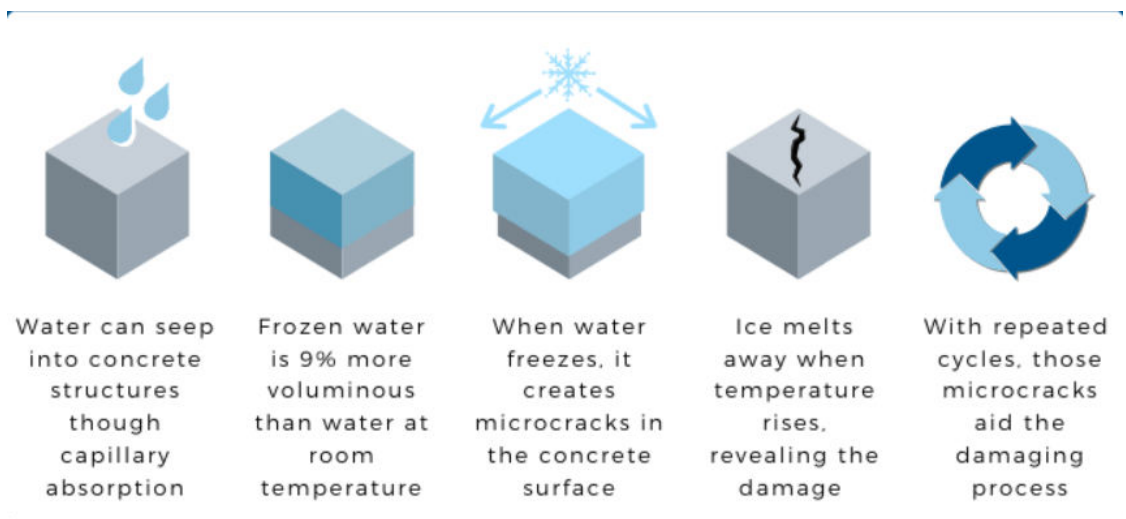
#### IV. OBSERVATIONS

##### 4.1 Biochar-Enhanced Concrete

- Strength: Optimal strength achieved with 10–15% biochar replacement.
- Durability: Improved resistance to water absorption, freeze-thaw cycles, and acidic environments.
- Carbon Sequestration: Demonstrated ability to lock carbon within the concrete matrix.

##### 4.2 M20 Grade Concrete

- Meets performance benchmarks as per IS 456:2000 standards.
- Moderate durability with resistance to sulfate attacks; improvements in water permeability are needed.
- Cement remains the largest contributor to its carbon footprint.



water absorption and freeze-thaw resistance for different concrete mixes.

## V. CONCLUSION

Integrating biochar derived from agricultural residues into concrete presents a sustainable alternative to conventional Portland cement. The study demonstrates that biochar improves mechanical properties, enhances durability, and sequesters carbon, significantly reducing the environmental footprint of concrete production. Furthermore, optimizing M20 grade concrete with biochar offers a viable solution to balance sustainability and structural performance, contributing to greener construction practices.



"Sustainability Roadmap for Concrete"

## REFERENCES

1. Siddique, R., & Chahal, V. (2018). Rice Husk Ash in Cement-Based Materials. Springer. |
2. Kiatkittipong, W., & Tu, C. (2019). Biochar for Concrete: A Review on the Utilization of Biochar as a Cementitious Material and in Concrete. *Materials*, 12(15), 2365. |
3. Habert, G., & Roussel, N. (2010). Environmental Impact of Portland Cement Production. *Journal of Environmental Management*, 91(12), 2875–2887. |
4. Lehmann, J., & Joseph, S. (2015). *Biochar for Environmental Management: Science, Technology and Implementation*. Routledge. |
5. Tan, Z., & Zheng, X. (2017). Utilization of Biochar in Concrete for Sustainable Development. *Journal of Cleaner Production*, 154, 92–101. |
6. IS 456:2000. Plain and Reinforced Concrete - Code of Practice. |
7. IS 10262:2019. Guidelines for Concrete Mix Proportioning. |
8. Mehta, P.K., & Monteiro, P.J.M. *Concrete: Microstructure, Properties, and Materials*. |
9. Neville, A.M. *Properties of Concrete*. |
10. ACI Committee 211. Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete.



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