Central Pulp & Paper Research Institute

IPPTA

Impact of Fibre Furnish, Biopolymer Surface Sizing, and Nanomaterials on the Biodegradability behaviour of Paper

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July, 2026

Outline of the Presentation

- Need for the study and research gap
- Major classes of Bio-polymers
- Raw material, Handsheets preparation and Biodegradability Test by Soil Burial Method
- Methodology of Surface Sizing and key results of Biodegradability Test of unsurfaced sized and surface sized paper
- Limitations/Future Work
- Conclusion

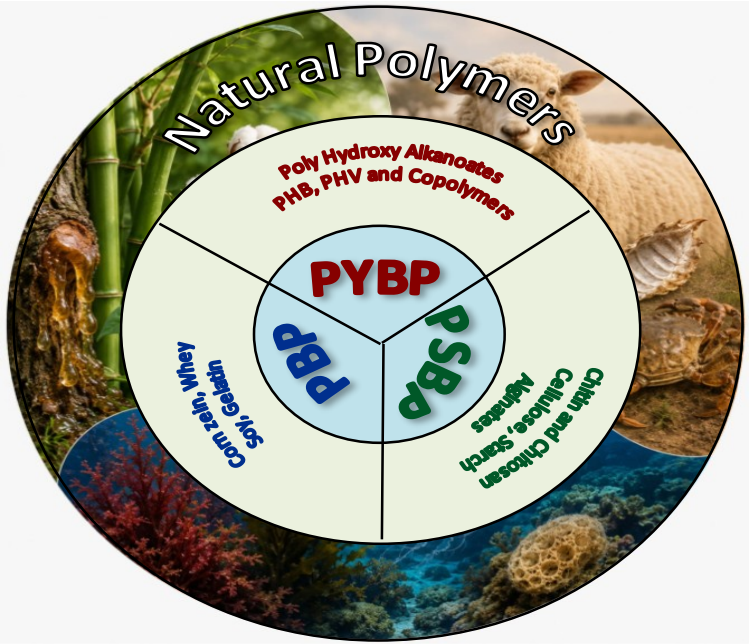
Need for the Study

- Paper-based packaging is a sustainable alternative to plastics due to its renewable, recyclable, and biodegradable nature.
- Surface modification using biopolymers and nanomaterials improves paper strength and barrier properties.
- These modifications may alter the biodegradation behaviour of paper after disposal.

Research Gap

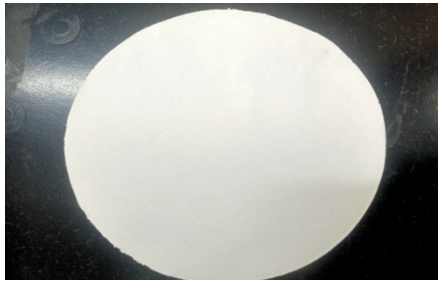
- Limited studies on the biodegradability of surface-modified paper.
- Lack of comparison between virgin wood pulp and recycled OCC paper.
- Combined effects of fibre furnish, biopolymer surface sizing, and nanomaterials are not well understood.
- Need for sustainable packaging with an optimum balance between performance and biodegradability

The Major Classes of Bio-Polymers



Illustrates the major classes of biodegradable polymers, categorized into natural polymer like Protein based biopolymer (PBP), Polyester based biopolymer (PYBP), and polysaccharide based biopolymer (PSBP).

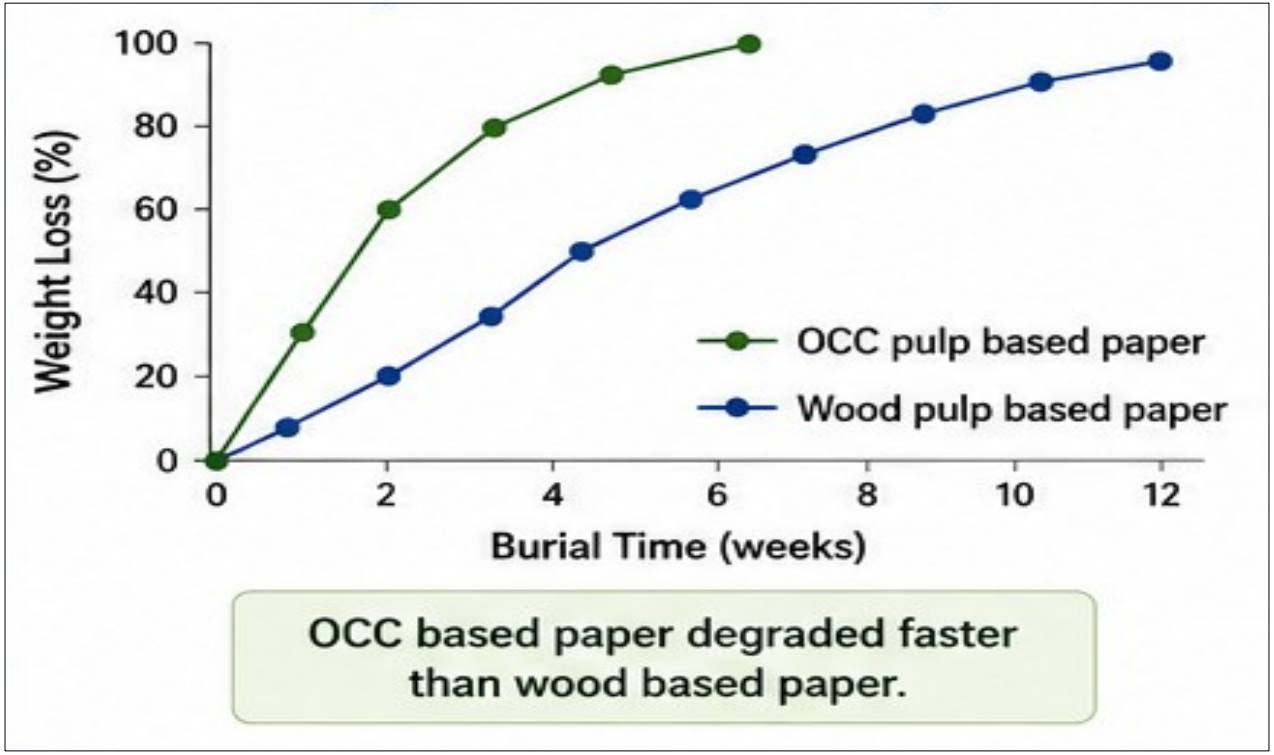
Raw Material and Handsheets Preparation



Biodegradability Test by Soil Burial Method

The soil biodegradation test was performed according to EN 14045:2003 to evaluate the biodegradability of paper samples. Biodegradation was determined by measuring the percentage weight loss of samples after soil exposure.

Key Results – Biodegradation of Uncoated Papers



Methodology of Surface Sizing Using Bio-Polymer

Biopolymer (Pro/anti Microbial) solution of 2% was Prepared

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Surface sizing was done on both base paper (OCC/Wood based) using laboratory pond size press

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The size pick Up was maintained as 45 ± 5 kg/ t

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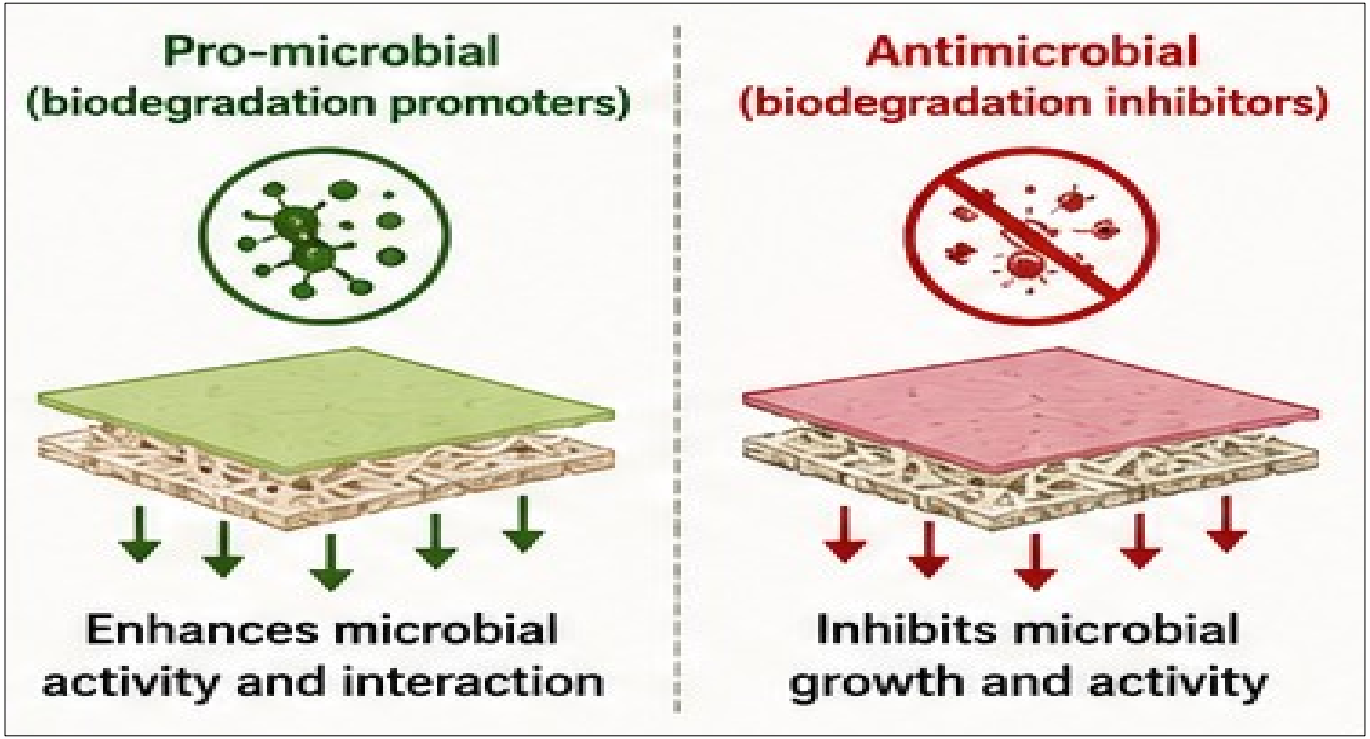
The base paper and surface sized paper were analysed for biodegradability testing by soil burial method

Surface Sizing and Bio-Polymers



Methodology of Surface Sizing Using Biopolymer and Nano Material(Nano Cellulose)

Biopolymer (Pro/Anti Microbial) solution of 2% was prepared

In the 2% solution of biopolymer 5% nano material (on solid basis of biopolymer was added)

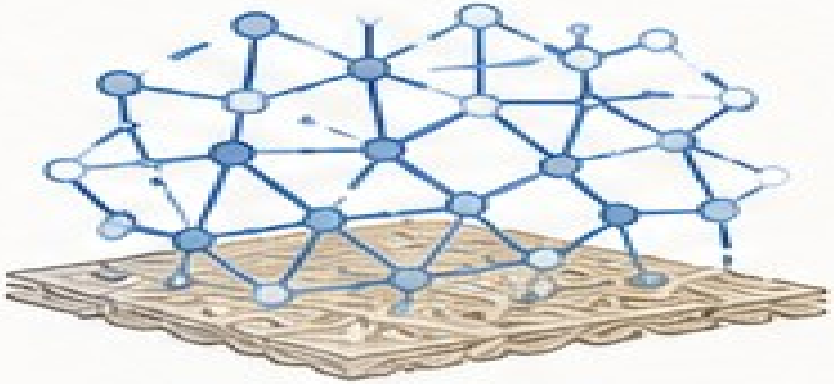
For proper mixing of nanomateiral and biopolymers the mixed solution was microfludized at 30,000 Psi using microfludizer

Surface sizing was done on both base paper (OCC/Wood based) using laboratory pond size press

The size pick Up was maintained as 45 ± 5 kg/ t

The base paper and surface sized paper were analysed for biodegradability testing by soil burial method

Incorporation of Nanomaterial

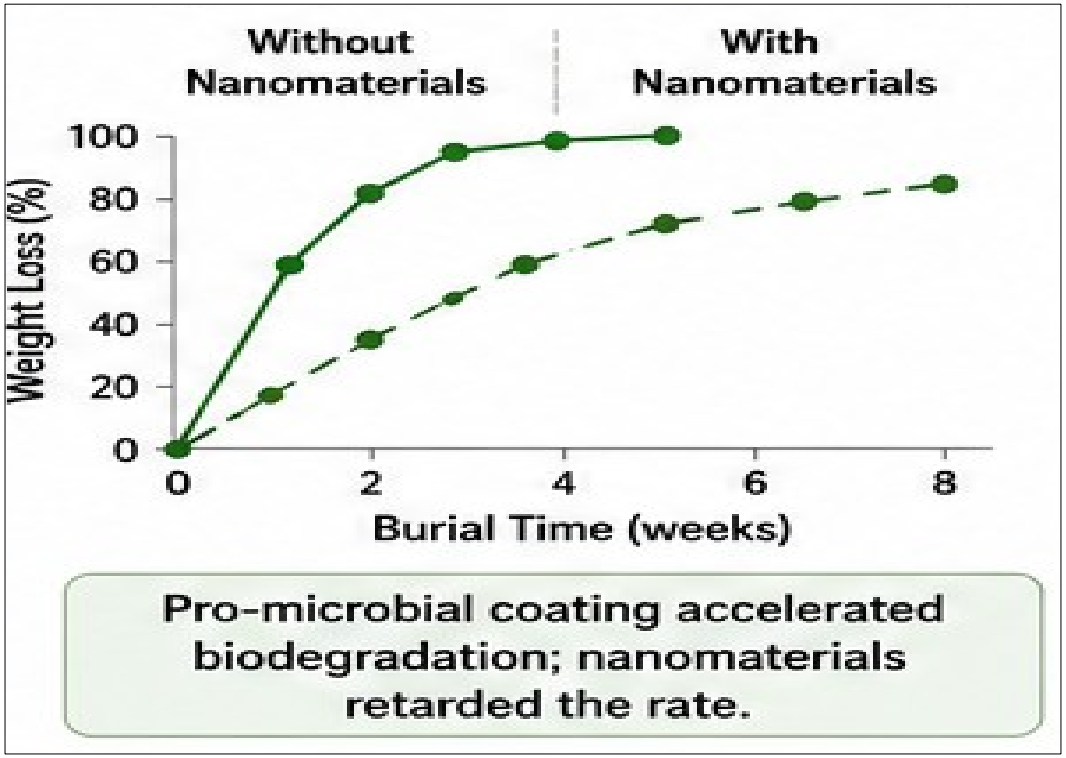


Nanomaterials fill pores and strengthen the surface structure, reducing porosity and moisture access, thereby retarding biodegradation.

Biodegradability of Handsheets made by using OCC and Wood Pulp with Surface sizing using Promicrobial Biopolymer alone and with Nano material

Sample/Time Period (week)	Biodegradability rate of paper (%)			
	OCC Pulp based paper		Wood Pulp based paper	
	Pro-microbial coated	Pro-microbial + nano coated	Pro-microbial coated	Pro-microbial+ nano coated
1 week	18-20	12-14	12-15	5-8
2 weeks	85-90	60-65	45-50	35-40
4 weeks	100	80-85	70-75	60-70
6 weeks	-	100	95-100	85-90
8 weeks	-		-	100

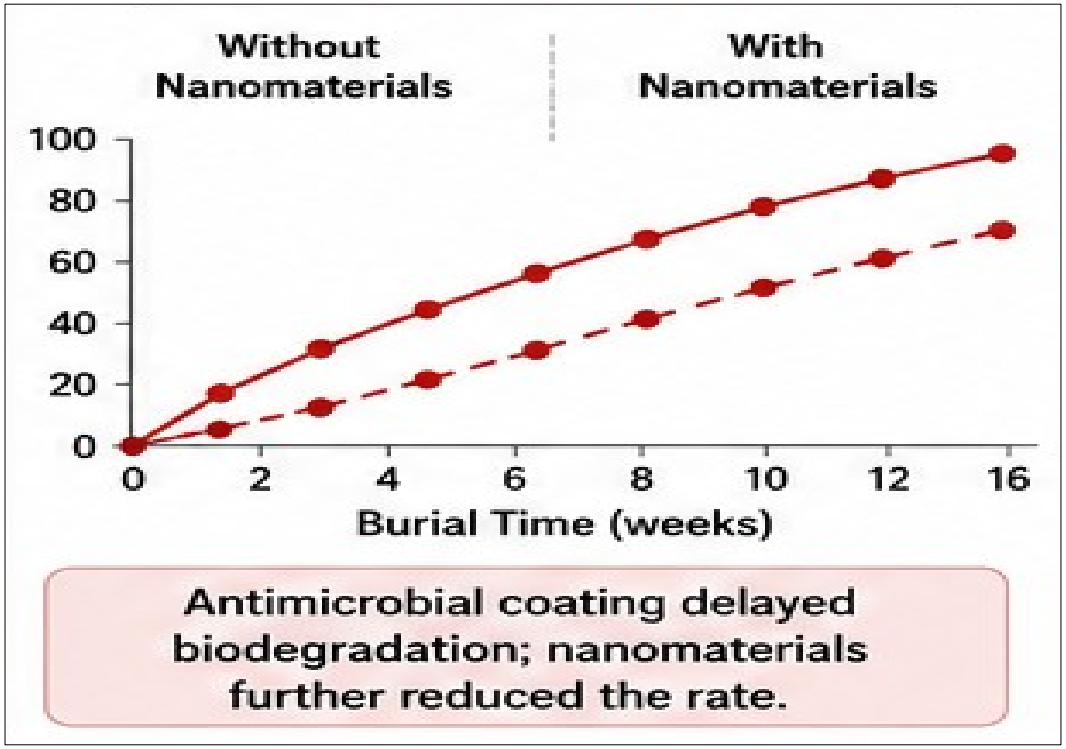
Key Results – Pro-microbial Biopolymer



Biodegradability of Handsheets made by using OCC and Wood Pulp with Surface Sizing using Antimicrobial Biopolymer alone and with Nano material

Sample/Time Period (week)	Biodegradability rate of paper (%)			
	OCC pulp based paper		Wood Pulp based paper	
	Anti-microbial coated	Anti-microbial coated+ nano	Anti-microbial coated	Anti-microbial coated+ nano
1 week	5-7	-	-	-
2 weeks	25-30	10-15	4-5	-
4 weeks	52-55	30-35	15-18	5-10
6 weeks	75-80	50-55	38-40	20-25
8 weeks	100	65-70	60-65	50-55
12 weeks	-	80-85	85-90	75-80
16 weeks	-	100	95-98	85-90
18 weeks				100

Key Results – Antimicrobial Biopolymer



Limitations/Future Work

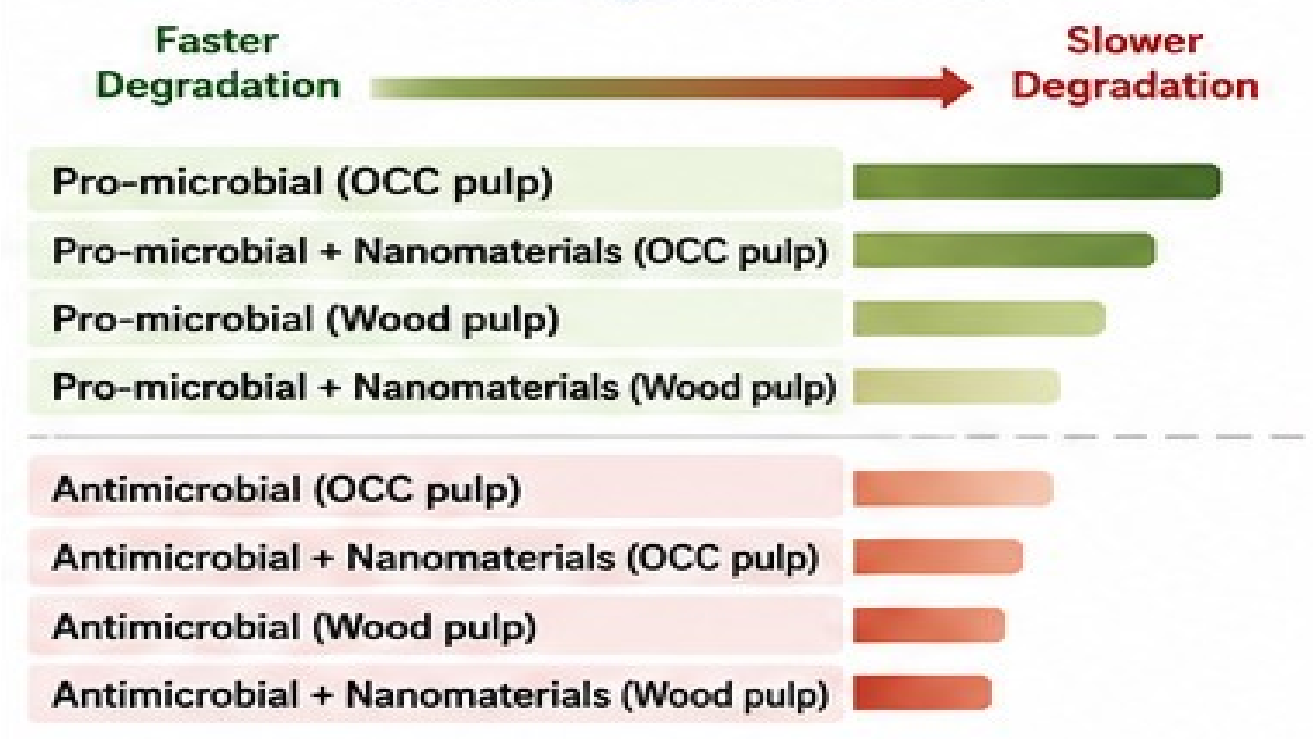
- SEM analysis was not performed, future studies will include SEM to better understand fibre degradation and structural changes during biodegradation.
- Biodegradation was evaluated using the soil burial (weight loss) method, providing a comparative assessment of different paper formulations.

Contd….

Limitations/Future Work

- As weight loss reflects both biological degradation and physical disintegration, the results indicate comparative rather than ultimate biodegradation.Future work will employ standardized methods such as ASTM D5338 (CO_2 evolution) for a more comprehensive evaluation of biodegradability.

Over All Degradation Trends



Conclusion

Fibre furnish significantly influences biodegradation: OCC > Wood pulp.

Pro-microbial biopolymer surface sizing enhances biodegradation.

Antimicrobial biopolymer surface sizing retards biodegradation.

Nanomaterials decrease porosity and moisture access, thus retarding biodegradation.

Appropriate combination of fibre furnish, biopolymer type and nanomaterials enables tailored biodegradability for sustainable paper-based packaging.

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