

A Narrative Review Of Microbial Strategies Of Medical Waste Degradation

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Structured Abstract

Background: Medical waste poses increasing threats to public health and the environment due to its complex composition and persistence. Traditional disposal methods such as incineration and landfilling release harmful byproducts, including microplastics and toxic emissions. Microbial degradation presents a promising sustainable alternative by utilising bacteria and fungi to enzymatically break down hazardous components, particularly plastics and pharmaceutical residues. However, the effectiveness of microbial degradation relies on optimised microbial strains, suitable environmental conditions, and an understanding of enzymatic mechanisms.

Methods: This review employed a narrative approach based on recent literature (2020–2025), focusing on microbial degradation of medical plastics, pharmaceutical residues, and biodegradable waste. Key microbial species such as *Pseudomonas*, *Aspergillus*, and *Bacillus* were examined for their degradation pathways and enzymatic profiles. Comparative analyses were conducted based on degradation rates, biofilm formation, enzyme types, and environmental adaptability in both aerobic and anaerobic systems.

Results: The findings revealed that *Enterobacter* spp. demonstrated the highest degradation efficiency on LDPE, achieving up to 81% weight loss over 120 days. *Aspergillus niger* showed consistent degradation of polyethylene microplastics via laccases and peroxidases, while *Pseudomonas aeruginosa* contributed through hydrolases and alkane hydroxylases. Engineered strains and microbial consortia further enhanced degradation and reduced toxic byproducts. However, incomplete degradation sometimes produces secondary pollutants such as microplastics, ARGs, and endocrine disruptors. Environmental factors like pH, temperature, and oxygen availability significantly influenced microbial performance. Real-time monitoring and co-treatment strategies were proposed to improve biodegradation outcomes and limit health risks.

Conclusion: Microbial degradation offers viable, eco-friendly alternatives for managing medical waste but faces limitations related to efficiency, scalability, and safety. Optimising microbial consortia, engineering enzyme systems, and mitigating byproducts are essential for practical application. This review highlights the potential of integrating microbial strategies into current medical waste management systems with further research and refinement.

Keywords: Medical waste, microbial degradation, plastic biodegradation, enzymatic pathways, sustainable waste management

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