Advanced Bioremediation of Plastic Pollutants Training Course

Professional Development Training Course Outline

Category	Biotechnology and Pharmaceutical Development	**Duration**	10 Days
Base Fee	$4,000 USD	**Delivery Mode**	Online / On-site Hybrid

Course Introduction

The accelerating crisis of plastic pollution, particularly the ubiquitous presence of microplastics and nanoplastics in every global ecosystem, demands urgent, sustainable, and technologically advanced solutions. Traditional waste management and physico-chemical recycling methods are insufficient to tackle the backlog of persistent polymer waste. This advanced training course dives deep into Environmental Biotechnology, focusing on next-generation, eco-friendly strategies specifically, advanced bioremediation to achieve complete polymer degradation. Bioremediation leverages the power of bioengineered microbial consortia and specialized plastic-degrading enzymes to mineralize recalcitrant plastic polymers, representing a paradigm shift toward a truly circular economy and Zero-Waste future. Advanced Bioremediation of Plastic Pollutants Training Course is essential for environmental professionals seeking to master the cutting-edge science and practical application of biological solutions for one of the planet's most critical environmental challenges.

This intensive course will equip participants with the skills to design, implement, and optimize robust biological systems for treating diverse plastic waste streams. Key areas of focus include synthetic biology applications for enzyme enhancement, the role of AI in microbial strain optimization, and the crucial move from laboratory-scale experiments to real-world, scalable industrial bioreactors. Mastery of these techniques is vital for driving global efforts in environmental sustainability, mitigating marine plastic litter, and achieving compliance with stringent international pollution regulations. Graduates will be prepared to lead projects in wastewater treatment, soil remediation, and the development of next-generation biodegradable polymers, positioning them at the forefront of the Green Technology revolution.

Programme Curriculum

Advanced Bioremediation of Plastic Pollutants Training Course

Introduction

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Course Duration

10 days

Course Objectives

1. Analyze the environmental fate and ecotoxicology of microplastics (MPs) and nanoplastics (NPs).
2. Master the principles of enzymatic degradation and microbial metabolism for recalcitrant polymers
3. Evaluate the latest breakthroughs in synthetic biology and genetic engineering for enhancing enzyme stability and catalytic efficiency.
4. Design and culture optimized microbial consortia for accelerated, multi-polymer plastic breakdown
5. Apply Bioinformatics and metagenomic analysis to identify novel, highly efficient plastic-degrading organisms
6. Develop effective pre-treatment strategies to enhance polymer susceptibility to biodegradation.
7. Design and operate various large-scale industrial bioreactors for ex-situ treatment.
8. Implement in-situ bioremediation techniques for contaminated soil and marine environments.
9. Utilize Machine Learning (ML) and AI models for predicting polymer biodegradability and optimizing bioprocess conditions.
10. Assess the potential for bio-upcycling plastic monomers into high-value chemicals as a part of a circular bioeconomy.
11. Interpret and apply international pollution regulations and Life Cycle Assessment (LCA) to bioremediation projects.
12. Design comprehensive monitoring and validation protocols using advanced analytical techniques to prove mineralization.
13. Formulate cost-benefit analyses for transitioning from traditional methods to cost-effective, low-carbon footprint bioremediation solutions.

Target Audience

1. Environmental Consultants and Engineers
2. R&D Scientists in Biotechnology and Materials Science
3. Waste Management and Recycling Industry Professionals
4. Regulatory Compliance and ESG Officers
5. Chemical and Petrochemical Industry Environmental Managers
6. Government and NGO Officials focusing on Plastic Pollution Policy
7. Academics and Researchers in Environmental Science
8. Process Engineers

Course Modules

Module 1: The Plastic Pollution Crisis and Remediation Landscape

- Global scale of plastic production and accumulation
- Ecotoxicological effects of plastic additives and breakdown products.
- Limitations of traditional physical/chemical recycling and thermal methods.
- The spectrum of bioremediation techniques
- Case Study: The Great Pacific Garbage Patch and the challenge of mixed marine plastic litter.

Module 2: Polymer Chemistry and Susceptibility to Biodegradation

- Structural classification of major commercial plastics
- Influence of crystallinity, molecular weight, and functional groups on degradation.
- Mechanisms of abiotic and biotic degradation.
- The role of plastic additives in microbial inhibition.
- Case Study: Comparative study on the biodegradation rates of PLA vs. traditional PET.

Module 3: Fundamentals of Microbial and Enzymatic Degradation

- The Plastisphere.
- Key microbial players: Bacteria, Fungi, and Algae.
- Enzyme classes: Hydrolases and Oxidoreductases.
- Kinetics of enzyme action
- Case Study: Discovery and characterization of PETase and its engineered variants for industrial application.

Module 4: Advanced Genetic Engineering for Enzyme Enhancement

- Techniques for heterologous expression and mass production of plastic-degrading enzymes.
- Rational design and directed evolution for improving enzyme thermostability and activity.
- Creating fusion proteins and immobilization on solid supports for reuse.
- Strategies to overcome enzyme inhibition and product accumulation challenges.
- Case Study: Engineering a hyper-efficient enzyme for continuous depolymerization.

Module 5: Bioaugmentation and Microbial Consortia Design

- Principles of synergistic degradation using microbial consortia over single strains.
- Screening and isolation of novel, highly-active indigenous microorganisms from diverse environments.
- Formulating and optimizing nutrient and growth conditions
- Techniques for creating stable, robust, and targeted mixed microbial cultures.

- Case Study: Field application of a specialized bacterial/fungal consortium for mixed plastic waste in a tropical landfill.

Module 6: Pre-treatment Strategies for Enhanced Biodegradation

- The necessity of pre-treatment to increase surface area and reduce crystallinity.
- Physical pre-treatments: Grinding, extrusion, and ultrasonication.
- Chemical pre-treatments: Alkaline hydrolysis, mild acid treatments, and oxidation.
- Abiotic factors: The use of UV irradiation and thermal exposure.
- Case Study: Pre-treating high-density polyethylene (HDPE) with UV-accelerated photo-oxidation prior to microbial exposure.

Module 7: Bioreactor Technology and Ex-Situ Applications

- Design and operational parameters for different bioreactor types
- Using immobilized enzymes and cells in column bioreactors for continuous flow.
- Slurry-phase and Solid-state fermentation systems for high-concentration waste treatment.
- Monitoring and control of critical parameters for maximum efficiency.
- Case Study: Design of a pilot-scale enzymatic bioreactor for processing large volumes of recycled PET flakes into monomers.

Module 8: In-Situ Bioremediation of Contaminated Sites

- Principles of Natural Attenuation and its limitations in plastic remediation.
- Biostimulation strategies for plastic-contaminated soils and sediments.
- Phytoremediation with plastic-associated plant-microbe systems
- Injection and distribution systems for delivering microbial cultures or nutrients into the subsurface.
- Case Study: Remediation project using nutrient injection to enhance native microbial activity at a historically contaminated soil site with buried plastic waste.

Module 9: Marine and Aquatic Bioremediation Strategies

- The challenge of marine plastic litter and the role of the ocean plastisphere.
- Designing floating or submerged platforms for enzyme/microbe containment and deployment.
- Treating plastic pollutants in wastewater treatment plants (WWTPs) and effluent streams.
- Addressing microplastic contamination in drinking water sources and marine food webs.
- Case Study: Development and field testing of a self-contained, immobilized enzyme system for mitigating plastic debris near coastal areas.

Module 10: Analytical Techniques for Monitoring Degradation

- Mass loss and physical observation for initial assessment.
- Spectroscopic analysis.
- Advanced techniques.
- Proof of complete mineralization.
- Case Study: Using GPC and C13-labeling to demonstrate the conversion of a plastic polymer to simple, non-toxic products.

Module 11: Artificial Intelligence and Machine Learning in Bioremediation

- Applying ML models to predict the biodegradability of novel polymers.
- Optimizing bioprocesses: AI for real-time control of bioreactor operating parameters.

- Automated high-throughput screening for novel enzyme and strain discovery.
- Using Bioinformatics to design synthetic gene pathways for enhanced catabolism.
- Case Study: AI-driven optimization of temperature and nutrient levels in a Pseudomonas bioreactor for accelerated polystyrene degradation.

Module 12: Bio-Upcycling and the Circular Bioeconomy

- The concept of upcycling depolymerized plastic monomers into valuable products.
- Production of bioplastics (PHAs) from plastic-derived monomers.
- Generating high-value biochemicals via microbial fermentation.
- Integrating bioremediation and Waste-to-Energy systems.
- Case Study: A company successfully closing the loop by bio-upcycling polyethylene-derived monomers into next-generation, high-performance biopolymers.

Module 13: Regulatory Landscape and Project Implementation

- Understanding the emerging International Legally Binding Instrument on Plastic Pollution
- Conducting a full Life Cycle Assessment (LCA) of bioremediation projects vs. incineration or landfill.
- Permitting, risk assessment, and public acceptance for large-scale environmental projects.
- Financial models and securing Green Investment and Carbon Credits.
- Case Study: Navigating regulatory approval for the first large-scale in-situ bioventing project for plastic contamination in a terrestrial ecosystem.

Module 14: Health, Safety, and Biosecurity in the Lab

- Safe handling and disposal of genetically modified organisms (GMOs) and microbial cultures.
- Personal protective equipment (PPE) and Biosafety Levels (BSL) for environmental labs.
- Mitigating the risk of pathogen emergence in bioremediation settings.
- Standard operating procedures (SOPs) for bioreactor start-up, monitoring, and shut-down.
- Case Study: Developing a biosecurity protocol for the controlled use of a novel, genetically engineered organism in a contained environmental remediation site.

Module 15: Future Directions and Emerging Technologies

- Integration with pyrolysis and solvolysis for hybrid remediation solutions.
- The potential of marine invertebrates for plastic breakdown.
- Developing biodegradable polymer alternatives with "on-demand" degradation triggers.
- The role of Nanotechnology in enhancing enzyme delivery and activity.
- Case Study: Research on developing a hybrid system combining low-temperature thermal pre-treatment with a robust enzymatic step for complex mixed plastic waste.

Training Methodology

The course employs an **Advanced Hybrid Learning** model, integrating theoretical mastery with practical, applied skill development:

1. Interactive Lectures & Seminars.
2. Case Study Analysis.
3. Laboratory Simulations.
4. Bioreactor Design Workshops.
5. AI/Bioinformatics Demos.
6. Capstone Project.

Register as a group from 3 participants for a Discount

Send us an email: info@fineskilltrainingcenter.org or call +254769199797

Certification

Upon successful completion of this training, participants will be issued with a globally- recognized certificate.

Tailor-Made Course

We also offer tailor-made courses based on your needs.

Key Notes

a. The participant must be conversant with English.

b. Upon completion of training the participant will be issued with an Authorized Training Certificate

c. Course duration is flexible and the contents can be modified to fit any number of days.

d. The course fee includes facilitation training materials, 2 coffee breaks, buffet lunch and A Certificate upon successful completion of Training.

e. One-year post-training support Consultation and Coaching provided after the course.

f. Payment should be done at least a week before commence of the training, to Fineskill Training Center account, as indicated in the invoice so as to enable us prepare better for you

Upcoming Scheduled Sessions

Start Date	End Date	Location	Price
23 Nov 2026	04 Dec 2026	Online	$2,000
23 Nov 2026	04 Dec 2026	Physical	$3,000
23 Nov 2026	04 Dec 2026	Physical	$6,000
23 Nov 2026	04 Dec 2026	Physical	$6,000
23 Nov 2026	04 Dec 2026	Physical	$12,000
23 Nov 2026	04 Dec 2026	Physical	$9,000
23 Nov 2026	04 Dec 2026	Physical	$12,000
23 Nov 2026	04 Dec 2026	Physical	$12,000

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