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Resistant Microbial Consortia in Contaminated Communities: Ecological Processes, Genomic Insights, and Biotechnological Prospects

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Abstract

Microbial populations play a fundamental role in nutrient cycling and maintaining ecosystem resilience in environments with pollutants of anthropogenic origin. Through this mini-review, the adaptable capacity, ecological processes, biotechnological perspectives, and genomic insights of microbial consortia present in contaminated freshwater and terrestrial systems are investigated. Recent advances in metagenomics, transcriptomics, and microbial ecology have provided valuable insights into microbial survival strategies under chemical stress, such as horizontal gene transfer, quorum sensing, and biofilm formation. The review categorizes microbes based on their degradative potential (e.g., hydrocarbonoclastic, heavy metal-reducing, xenobiotic-tolerant) and elaborates on how these characteristics can be utilized for soil remediation, water purification, and atmospheric detoxification. Special focus is given to the functional interaction between native microbiota and supplemented bioengineered strains for enhanced bioremediation efficiency. Ecological restoration, climate change mitigation, and environmental policy design consequences are also discussed. Lastly, understanding microbial ecosystem resilience and utility provides a promising avenue towards sustainable environmental management.

Keywords: *Microbial ecology, Environmental resilience, Bioremediation, Contaminated habitats, Metagenomics, Microbial biotechnology*