Microbial Biodegradation and Nanomaterial-Based Oil Removal Strategies for Marine Oil Spill Remediation

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Marine oil spills pose severe ecological and economic challenges, necessitating effective remediation strategies. This study explores the interplay between microbial diversity shifts and oil degradation efficiency in marine ecosystems following oil spills. Through next-generation sequencing (NGS), we analyzed microbial community responses to hydrocarbon contamination in a heavily polluted coastal region. Our findings reveal that indigenous bacteria, particularly *Staphylococcus saprophyticus* and *Bacillus megaterium*, significantly contribute to the biodegradation of hydrocarbons, including unresolved complex mixtures (UCMs). Additionally, we evaluated an innovative green-technology approach using hydrophobic crystalline calcite nanoparticles for oil-water separation. The synthesized calcite exhibited near-superhydrophobicity and demonstrated rapid and efficient oil adsorption, with over 99% removal efficiency. The results suggest a dual strategy of bioremediation and advanced nanomaterials as a sustainable and cost-effective approach to mitigate oil spill contamination. This study underscores the importance of integrating microbial ecology with engineered materials for enhanced environmental recovery.

Keywords: Marine oil spill, Microbial biodegradation, Hydrocarbon removal, Nanomaterial adsorption, Environmental remediation

