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Bio Degradation of Polymers and Metal Pollutants by Different Microorganisms: A Mini Review on Biodegradation: An Eco-Friendly Approach

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Abstract: ***Biodegradation, the microbial breakdown of organic materials, offers an eco-friendly solution to the growing challenge of polymer waste. This mini review explores the role of microorganisms in degrading aromatic hydrocarbons and synthetic polymers, emphasizing biodegradation's cost-effectiveness in tackling xenobiotics. It outlines the process's three key stages—biodeterioration, bio fragmentation, and assimilation—alongside the critical roles of enzymes, microbes, and environmental conditions. The review also highlights methods to assess polymer biodegradability, underscoring the importance of integrating new materials into biogeochemical cycles for sustainable waste management. It also emphasizes different microorganisms along with polymers and heavy metals that is degraded by the respective microbes.***

Keywords: Biodegradation, Biodeterioration, Bio fragmentation, Assimilation, Polymer degradation, Xenobiotics

1. Introduction

As technology has advanced and the global population has grown, plastics have become increasingly prevalent in a wide range of products, whether for everyday domestic or commercial use. Numerous discarded polymer products pose a serious threat to the environment. Polymer products that contribute to ecological pollution and landfill waste that eventually finds its way into an open and uncontrolled environment, given the sharp rise in demand for these polymers and their supply. It is generally acknowledged that traditional plastics, which are usually derived from fossil fuels, can persist in the marine environment for hundreds of years. Additionally, additives related to plastic products, like phthalate plasticizers, can adsorb onto and leak out of degraded plastic marine debris, leading to a build-up of toxicity in the marine food web. Exposure to phthalate plasticizers during a plastic product's use is known to have detrimental effects on human neurodevelopment and reproductive health before disposal.[1, 2] Two new pollutants that interact with one another in designed and environmental systems are micro plastics and organic micro pollutants. The bioavailability and biodegradation of micro plastics can be altered by the sorption of organic micro pollutants, including industrial chemicals, pesticides, and medications.[3] The process by which microorganisms like bacteria and fungi break down organic matter is known as biodegradation.[4] It is considered a natural process, which sets it apart from composting. Composting is a human-driven process where biodegradation takes place under particular conditions.[5] Chemical design and use must shift to a sustainable approach in light of chemical pollution, which poses a serious threat to our ecology. Early in the design phase, the end-of-life and environmental fate of a chemical must be considered if it is necessary for a specific purpose. Fewer researches have examined the environmental biodegradation of natural compounds, despite the fact that many have examined their activity. [6]The detrimental effects of polyaromatic hydrocarbons (PAHs) on a variety of ecosystems make them a global hazard to both industrialized and developing nations. Frequently utilized in daily life, low molecular weight (LMW) PAHs have the potential to be harmful substances. They require an efficient biodegradation system because they are extremely volatile and frequently absorbed by plants and make their way into the food chain.[7]When compared to thermoplastics, thermosets are exceptional polymeric materials that are typically distinguished by their higher modulus and stress at break, chemical resistance, and thermal stability. There are many uses for thermosets, particularly in the construction of long-lasting items including electrical components, storage boxes, medical equipment, pipelines, and parts of automobile. A lot of work has recently gone into redesigning the chemical structure of thermosets by substituting dynamic covalent linkages, such ester and ammine bonds, among others, for some of the permanent covalent bonds. Under the right circumstances, this can allow for reprocessing.[8]Unlike thermoplastics, which only have secondary contacts between neighboring macromolecule chains, thermostats have superior characteristics mostly due to the presence of covalent cross links between the macromolecule chains, which cause a network to develop. Thermostats, especially those made from bio based resources, have the disadvantage of not meeting the standards of a circular economy because of their low capacity for recycling, which at best results in energy recovery or down cycling. Materials made of polymers are now necessary for our daily existence. Therefore, it is not feasible to completely eliminate them from our way of life, but there are steps that may be taken to slow the rapid accumulation of synthetic polymers. Less than 10% of the 460 million tons of plastic produced year