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Biological Treatment of Landfill Leachate Using Native Microalgae

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Extended Abstract:

The rapid growth of municipal solid waste (MSW) continues to pose major environmental challenges, with more than 95% of MSW still disposed of in landfills [1]. Landfills generate leachate, a highly contaminated liquid containing organic matter, heavy metals, ammoniacal nitrogen, and refractory compounds such as humic and fulvic acids [2]. The composition of leachate varies with age, with young leachate (<5 years) rich in biodegradable organic matter, while mature leachate (>10 years) contains persistent pollutants that are harder to degrade [3]. If untreated, leachate infiltrates soil and water, contaminating groundwater and surface water and posing risks to ecosystems and human health [4]. Conventional treatment processes, while widely applied, are often costly, energy-intensive, and limited in their ability to handle the complex pollutant load of landfill leachate. In contrast, microalgae present a promising eco-friendly alternative, capable of nutrient and heavy metal removal while simultaneously producing biomass that can be used for biofuels and bioproducts [5]. This study therefore aims to explore the potential of native Omani microalgae for the biological treatment of landfill leachate. Native strains will be isolated from local water bodies, identified using Next Generation Sequencing (NGS), and tested under controlled experimental conditions. Stock cultures of selected strains will be exposed to three different leachate concentrations (5%, 10%, and 15%) for four days under a 12:12 light-dark cycle at 5000 Lux. Algal growth will be monitored daily via spectrophotometry at OD 680 nm, while comprehensive analyses will be performed on initial and final samples, including COD, BOD, TSS, TDS, DOC, DIC, pH, and turbidity [6]. Heavy metals will be quantified using ICP-OES, and species identification will be validated through NGS. A control will be maintained for accurate comparison. It is expected that efficient strains such as *Chlorella pyrenoidosa, Chlorella vulgaris, Chlamydomonas snowiae, Galdieria sulphuraria, Tetradesmus obliquus, Scenedesmus spp.,* and *Microcystis spp.* may be isolated and show significant removal efficiencies for COD, BOD, ammonia, phosphorus, and heavy metals [7]. In addition to pollutant reduction, the system offers a low-cost and sustainable nutrient removal process where microalgae utilize CO_2, thereby contributing to greenhouse gas mitigation [8]. The resulting biomass further supports a circular economy by providing feedstock for biofuels, fertilizers, food supplements, and other value-added products [9]. Overall, this research highlights the dual benefit of microalgal treatment in addressing environmental pollution while contributing to renewable bioresource generation. By leveraging native species adapted to local conditions, the approach enhances resilience and cost-effectiveness compared to conventional methods, providing a model for sustainable waste management in Oman and beyond. The outcomes are expected to contribute to net-zero strategies while demonstrating the broader role of biotechnology in turning pollution into a valuable resource, advancing both environmental protection and economic sustainability.

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