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Bioremediation of Power Plant Wastewaters Using Microalgae

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Structured Abstract

Background: Industrial wastewater discharge from power plants poses significant environmental risks due to high organic loads, suspended solids, and toxic heavy metals that are inadequately removed by conventional treatment methods. Microalgae-based bioremediation has emerged as a sustainable alternative due to its low energy demand, ability to assimilate nutrients and pollutants, and potential to generate valuable biomass. *Chlorella vulgaris* is particularly attractive for wastewater treatment owing to its tolerance to harsh conditions and high biosorption capacity.

Methods: *Chlorella vulgaris* was cultivated under controlled laboratory conditions in three media: distilled water supplemented with bio-compost (control), power plant effluent, and power plant oily effluent. Growth performance was monitored using optical density and biomass concentration. Bioremediation efficiency was evaluated through the removal of chemical oxygen demand (COD), total suspended solids (TSS), and selected heavy metals (Fe and Cd). Biomass was harvested by flocculation and characterized using CHNS-O elemental analysis and ATR-FTIR spectroscopy to assess energy potential and functional groups involved in metal binding.

Results: *Chlorella vulgaris* successfully adapted to both wastewater media, although growth and biomass productivity were lower than in the control. Final biomass concentrations reached approximately 1.16 g L^{-1} in power plant effluent and 1.32 g L^{-1} in oily effluent, indicating enhanced biomass accumulation in the presence of organic compounds. COD removal efficiencies of 72.2% and 59.1% were achieved for power plant effluent and oily effluent, respectively, while TSS removal exceeded 57% in all media. Moderate iron removal (46.7%) was observed in oily effluent, whereas cadmium removal was limited due to competitive ionic effects. FTIR analysis confirmed the presence of functional groups associated with biosorption mechanisms.

Conclusion: The findings demonstrate that *Chlorella vulgaris*, particularly when cultivated in power plant oily effluent, is a promising and sustainable agent for industrial wastewater bioremediation while producing biomass with potential downstream applications.

Keywords: Microalgae bioremediation, *Chlorella vulgaris*, industrial wastewater, chemical oxygen demand removal, heavy metal uptake

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