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Immobilized *Scenedesmus regularis* for enhanced biosorption of zinc oxide nanoparticles

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Zinc oxide (ZnO) nanoparticles are among the most widely used nanoparticles as ingredients in various products. These nanoparticles often enter the water bodies through industrial discharge and other means. Once they reach into the water, they remain there for longer time and show toxicity to aquatic flora, fauna and even human beings upon exposure. Despite their potential hazards, the removal of nanoparticles from the environment has not been extensively studied, making it a pressing issue for both human health and the environment. Driven by this need, the present study has undertaken to develop a biosorption method using immobilized *Scenedesmus regularis* green microalgae to remove ZnO nanoparticles. In this research, environmentally isolated microalgae were characterized using 18S rRNA gene sequencing. The ZnO nanoparticles were chemically synthesized and characterized through Fourier transform infrared spectroscopy (FTIR), transmission electron microscopy (TEM), and X-ray diffraction (XRD). Batch sorption experiments were conducted to demonstrate the efficiency of *Scenedesmus regularis* in absorbing ZnO nanoparticles under various conditions. Statistical analysis using one-way ANOVA was conducted to compare conditions before and after biosorption. The 18S rRNA gene sequencing confirmed that the isolated species was *Scenedesmus regularis*. ICPMS results showed that the immobilized *Scenedesmus regularis* microalgal biomass, encapsulated in sodium alginate beads, effectively removed 82.53% of ZnO nanoparticles at an initial concentration of 80 mg/L within 3 h. FTIR analysis revealed that carboxyl, amine, hydroxyl, sulfate, and sulfonate functional groups on the *Scenedesmus regularis* cell wall played a significant role in binding ZnO nanoparticles. Additionally, SEM-EDX imaging confirmed the attachment of ZnO nanoparticles to the surface of *Scenedesmus regularis* cells. The results of the adsorption/desorption studies showed that the *Scenedesmus regularis* biosorbent could be regenerated many times with no extensive reduction in ZnO nanoparticles' adsorption percentage. Present study exposed to provide an alternative to conventional wastewater treatment techniques. This research focuses that *Scenedesmus regularis* as a biosorbents appeared to be more efficient to uptake of ZnO nanoparticles and has a potential to be reused for multiple cycles of nanoparticles uptake. The study aims to eliminate toxic nanoparticles from aqueous environments through microalgae biosorption. This method is efficient, natural, safe, eco-friendly, and more economical.

Keywords: Adsorption, Desorption, Nanoparticles, Matrix-coupled, *Scenedesmus regularis*