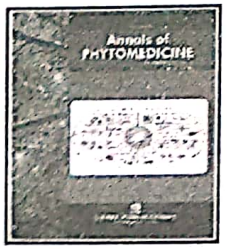
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Green synthesis and phytomedicinal potential of *Eichhornia crassipes* (Mart.) Solms: A comprehensive review

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Abstract

Eichhornia crassipes (Mart.) Solms, commonly known as water hyacinth, is one of the world's most pervasive invasive aquatic macrophytes, causing enormous ecological disruption in tropical and subtropical freshwater ecosystems. Despite its notorious status as a noxious weed, mounting scientific evidence over the last decade has repositioned this plant as a valuable reservoir of bioactive phytochemicals and a versatile platform for green nanotechnology. This comprehensive review consolidates current knowledge on the phytochemical composition of *E. crassipes*, encompassing primary metabolites (proteins, lipids, and carbohydrates) and a diverse array of secondary metabolites, including phenolics, flavonoids, alkaloids, tannins, and saponins. The review critically examines plant-mediated (green) synthesis of silver (AgNPs), gold (AuNPs), and zinc oxide nanoparticles (ZnONPs) using aqueous extracts of *E. crassipes*, detailing the role of phytochemicals as natural reducing and stabilizing agents and the characterization of these nanoparticles using UV-Vis spectroscopy, Fourier-transform infrared spectroscopy (FTIR), X-ray diffraction (XRD), and electron microscopy (SEM/TEM). The biological and pharmacological activities of the plant, including antioxidant, antimicrobial, anti-inflammatory, and anticancer potential, are systematically reviewed. Furthermore, the environmental and economic applications of *E. crassipes* in wastewater phytoremediation, bioenergy production, and agricultural valorization are assessed within the framework of the circular bioeconomy. Challenges related to standardization, phytochemical variability, safety, and ecological risk are discussed, and future research directions towards sustainable utilisation of this invasive species are proposed. This review underscores the dual identity of *E. crassipes*: A formidable ecological threat and an untapped phytomedicinal and nanotechnological resource.

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