

Plant Based Nanomaterials for Sustainable Water Purification

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Abstract: In addition to the benefits of recyclability and biologically informed building of specific nanomaterials, a number of avenues are available to enhance water treatment capabilities via plant sources. The aim of this paper is to critically review the plant-extract mediated iron and zinc oxide nanoparticles, cellulose nanofibers and carbon nanomaterials produced from biomass. A selected primary study was targeted and the outcome compared with regard to synthesis routes, contaminant-removal mechanisms, treatment performance and practical limitations. There are published applications that include: metal-ion capture, oil-water separation, nitrate removal, dye photodegradation, and chromium reduction. Reported removal percentages, however, are for different pollutants and operating conditions and are not applicable for ranking materials in general. Four requirements for credible claims concerning sustainability of feedstock processing, of testing of the water-matrix, of material recovery and of assessment of energy use and secondary waste are identified in the analysis. The use of immobilized composites and reusable membranes offers practical solutions to keep active nanomaterials in place but still need to look into the mechanical stability and longevity of these solutions. Environmental safeguards and reduction of life-cycle impacts are not determined by plant origin. Future studies should be conducted to compare the performance of full treatment systems with contaminant mass balances, residual-particle, regeneration data and cost per volume of compliant water produced. The review indicates plant-based nanomaterials have the potential to be used as elements of integrated water-treatment systems, but their use will rely on the demonstrated performance and environmental advantages.

Keywords: plant-mediated synthesis; nanocellulose; carbon dots; photocatalysis; adsorption; wastewater treatment; sustainability.