



Eco-Friendly Silver Nanoparticles from *Syzygium cumini* for Aquatic Environmental Remediation: Catalytic and photocatalytic Degradation of p-Nitrophenol and Methyl Orange alongside Cytotoxicity Assessment

Premiya Mohanraj, Mathivathani Kandiah*, Beneli Gunaratne, Ominda Perera

¹Faculty of Life and Medical Sciences, BMS Campus, Colombo 6, Sri Lanka.

*mathi@bms.ac.lk

Nanotechnology has transformed strategies for managing aquatic pollution by introducing metal-based nanoparticles with remediation capabilities. This study focused on the green synthesis of silver nanoparticles (AgNPs) from five different plant parts of *Syzygium Cumini*, madan (leaf, fruit, peel, stem, bark, and root), evaluated for cytotoxicity, reduction of para-nitrophenol (PNP), and photocatalytic degradation of methyl orange (MO). Scanning Electron Microscopy revealed irregular cuboidal-shaped Fruit-based AgNPs of size 30-60 nm, which exhibited a zeta potential of -16.8 mV. The catalytic activity of the AgNPs was assessed through the reduction of para-nitrophenol (PNP) to para-aminophenol (PAP) using sodium borohydride (NaBH₄) as the reducing agent, monitored by UV-Vis spectrophotometry. Among all samples, fruit-based AgNPs exhibited the highest catalytic efficiency, with a maximum rate constant of $k = 0.1100 \text{ min}^{-1}$ (50 μL , 4000 ppm) and 0.0510 min^{-1} (75 μL), achieving complete degradation within 10–20 minutes. Further, the photocatalytic studies demonstrated effective degradation of methyl orange (MO) under sunlight, particularly in the presence of NaBH₄, where fruit based AgNPs achieved a rate constant of 0.065 min^{-1} , when 500 μL of 4000 ppm AgNPs was added to 50 mL of 4000 ppm MO, indicating enhanced electron transfer and reduced activation energy. The catalytic mechanism is attributed to the adsorption of reactants onto the AgNPs surface, facilitating electron transfer from BH₄⁻ to PNP. Cytotoxicity assessment using the Brine Shrimp Lethality Assay revealed 100% viability at 200 ppm and 800 ppm solutions of AgNPs in seawater, indicating negligible toxicity and high biocompatibility of the synthesized nanoparticles. Overall, biosynthesized AgNPs from *Syzygium cumini* demonstrate superior catalytic performance with minimal cytotoxicity, highlighting their potential for sustainable environmental remediation.

Keywords: Silver nanoparticle, *Syzygium cumini*, Photocatalytic degradation, Cytotoxicity