Abstract

In a world where the growing challenge of microbial resistance to traditional antibiotics and the urgent need for sustainable healthcare solutions persist, this study conducts a significant investigation into the synthesis and utilization of copper nanoparticles. The research delves into a captivating intersection of nanotechnology, biology and sustainability, offering a potential breakthrough in the field of antimicrobial treatments. Using a green synthesis approach, copper nanoparticles were synthesized with the aid of *Piper nigrum* extract as a reducing and stabilizing agent. Analysis revealed an absorption peak at 310 nm and functional groups through Fourier Transform Infrared Spectroscopy. Scanning Electron Microscopy displayed their rod-like shape. Drug entrapment efficiency ensured controlled release. Kinetic models showed favorable behavior, particularly the Korsmeyer Peppas model signifying non-Fickian release. These nanoparticles exhibited potent antimicrobial properties, inhibiting various bacteria and fungi.For *Escherichia coli*, Ampicillin-loaded copper nanoparticles exhibited a substantial zone of inhibition measuring 33 mm suggesting a notable enhancement in antibacterial activity compared to Ampicillin alone. In case of fungi, the most significant inhibition zone of 32 mm was observed for fluconazole-loaded copper nanoparticles. Combined with antibiotics, they demonstrate remarkable synergistic effects, promising advanced pharmaceutical formulations suggesting exciting prospects. This study highlighted the substantial significance of green-synthesized copper nanoparticles to address the imperative challenges of microbial infections.