**Abstract**

In this research work, silver nanoparticles (AgNPs) were prepared using green procedure and loaded on Hildegardia barteri activated carbon (HBAC) and then characterized for determination of morphology, crystals structure, functional groups, surface area and porosity, and size distribution, of the composite material using Scanning electron microscope equipped with energy dispersive X-ray spectroscopy (SEM-EDX), X-ray diffraction (XRD), Fourier-transform infrared spectroscopy (FTIR), Brunauer Emmett Teller (BET), and High-resolution transmission electron microscope (HRTEM). The AgNPs/HBAC nanocomposite was used for the removal of Congo red (CR) dye from aqueous solution. The antimicrobial activity of AgNPs/HBAC was tested against Pseudomonas aeruginosa, Salmonella typhi, Escherichia coli and Bacillus subtilis bacteria using the agar well diffusion method. Parameters such as initial CR concentration (20–100 mg/L), adsorbent dosage (0.1–1 g), contact time (0–90 min), and adsorption temperature (308, 318 and 328 K) were investigated on a batch adsorption process to estimate the CR removal efficiency. The mesoporous AgNPs/HBAC had a BET surface area of 794 m2/g which enhanced CR adsorption capacity (161.29 mg/g). The Freundlich isotherm emerged the best fitted model, indicating surface heterogeneity (multilayer adsorption) between the CR and AgNPs/HBAC surface. The CR adsorption onto AgNPs/HBAC was adequately described by a pseudo-second order kinetic model, and the overall adsorption process was governed by Webber-Morris intraparticle diffusion, and liquid film diffusion models. Thermodynamic study revealed that the adsorption ability of AgNPs/HBAC toward CR was spontaneous, feasible, and exothermic. The developed AgNPs/HBAC could be used as a nano-adsorbent to mitigate the environmental problems caused by CR in wastewater. Regeneration and reusability of AgNPs/HBAC adsorption performance indicated adsorption efficiency greater than 85 % after five successive cycles.