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Studies of new metallic nanoparticles: Synthesis, characterization and their applications

There are seven chapters in the research findings. **First chapter** is about the Introduction, It discusses the causes of water pollution, including point and non-point sources, as well as different types of water pollutants, including inorganic, organic, and biological ones, and the health risks they pose to people. It also includes information on cationic as well as anionic dyes, HMIs, pesticides, antibiotics, and their effects on people, as well as the effects of heavy metals on human health. The methods for water purification are then described, along with pros and cons for each, including zeolite, flocculation, sedimentation, ion exchange reverse osmosis, distillation, biological treatment, membrane separation, and adsorption. Adsorption is covered along with the following topics: adsorbent, types of adsorbents, including nano adsorbents, and the mechanism of adsorption. A detailed literature review of the previously published research related to the theme of the present thesis is discussed followed by the outline of the thesis.**Second chapter** is about different synthesis and characterisation methods of metallic nanoparticles. It describes several methods to synthesize metal and metal oxide nanoparticles, such as hydrothermal, microwave-assisted, sol-gel, co-precipitation, etc. The characterisation methods for nanoparticles along with polymer-based nanocomposites are also covered in this chapter. The effects of adsorbent dose, initial adsorbate concentration, pH, batch equilibrium study findings, adsorption isotherms, and adsorption thermodynamics are a few parameters that are taken into consideration when conducting batch mode adsorption studies. **Third chapter** addresses Vernonia cinerea mediated nickel nanoparticles (SNPs),which are biosynthesized with the help of phytoconstituents found in ethanolic extract of the *Vernonia cinerea* plant SNPs were characterized using XRD, FT-IR, and HR-FESEM. SNPs were observed crystalline in natureas confirmed by XRD investigation. The SNPs were used as bio- Nanoadsorbents to remove dyes from aqueous environments, such as cationic (BG) and anionic (CR) dyes. The maximal adsorption capacity (q_m) for BG dye and CR dyes was determined to be 1666.7 mg g^{-1} and 666.7 mg g^{-1}, respectively. Monolayer adsorption was advised when the Langmuir isotherm coefficient was larger. With $R^2 > 0.99$ for both dyes, the adsorption kinetics data was usefully suited to pseudo-second order kinetics. SNPs have shown to be effective sorbents for the removal of dyes from aqueous environments and can be used to eliminate discharges from textile and tanneries. Studies also conducted to investigate the antimicrobial efficacy of SNPs.The *in vitro* antifungal efficacy was investigated on multiple strains of *Candida*. Results demonstrated dose-dependent inhibitory responses of SNPs that could be used as nanomedicine to treat various fungus strains. Overall, this study demonstrates that the use of SNPs as a bioadsorbent to remove organic effluents from water bodies is secure, environmentally benign, and cost-effective. **Fourth chapter** deals with the development of nickel nanoparticles (BNPs) using ethanolic extract of (*Tricholepis glaberrima*). BNPs were used as an adsorbent for the removal of methyl orange (MO) along with brilliant green (BG) from aqueous solution. Nickel nanoparticles produced through biogenic synthesis were preferred because of their cost-effectiveness, rapidity, and ecological makeup. The whole plant extract functions as a potent reducing, stabilising, and capping agent. The maximum adsorption capacities (q_m) of BG dye and MO dyes were found to be 370.37 mg g^{-1} and 312.5 mg g^{-1}, respectively. It was suggested to use monolayer adsorption when the Langmuir isotherm coefficient was higher. The

adsorption kinetics data were well corelated to pseudo-second order kinetics since R^2 was greater than 1 for both dyes. Due to its large surface area and abundance of functional groups, BNPs demonstrated adsorption capacity for both cationic and anionic dyes. *In vitro* antifungal efficacy of BNPs' was studied on multiple strains of *Candida*. BNPs displayed dose-dependent inhibitory responses that could be exploited as nanomedicine to treat diverse fungi strains. **Fifth chapter** reports the development of novel WO_3@BLP bionano composite for wastewater treatment. It had been demonstrated through batch adsorption evaluations that it was environmentally safe, and economically viable adsorbent for the removal of CR as well as CV dye from synthetically generated wastewaters. FESEM (Field Emission Scanning Electron Microscopy), HR-TEM (High-resolution Tanning Electron Microscopy), FTIR (Fourier Transform Infrared Spectroscopy), XRD (X-Ray Diffraction), and TGA (Thermogravimetric analysis) were used to evaluate and identify WO_3@BLP nanocomposite. By adjusting the initial adsorbate concentration (10-250 mg L^{-1}), WO_3@BLP dose (0.2 to 0.7 g), solution pH (1–10), and WO_3@BLP dose (0.2 to 0.7 g), the effectiveness of WO_3@BLP nano-adsorbent for the removal of CR along with CV dyes was examined. The dye elimination percentage rose as WO_3@BLP dose was raised. The adsorption of CR as well as CV dye onto nanoadsorbents was found to have an equilibrium period that ranged from (10-250 min) and was reached at 150 min. Based on the coefficient correlation (R^2) values of 1 for both CR and CV dyes, the Langmuir isotherm showed a better fit. Maximum adsorption capacities of 833.3 and 625 $mg.g^{-1}$ for CR and CV, respectively, were displayed. Kinetic study revealed that the pseudo-second order (PSO) model exceeded thepseudo-first order(PFO) model. Additionally, the values of the thermodynamic parameter showed that endothermic, spontaneous, and thermodynamically stable CR and CV adsorption onto the WO_3@BLP bionano composite. Therefore, the results suggested that WO_3@BLP, a synthetic bionanocomposite, could be used as a potential adsorbent for the removal of cationic as well as anionic dyes from water samples. **Sixth chapter** is about the development of L-ascorbic acid doped polyaniline@MnO_2 nanocomposite. It revealed the development of a multifunctional nano composite as an adsorbent made of polyaniline, MnO_2 nano particles, and L-ascorbic acid using the *in-situ* polymerization technique. Nanocomposite was used to increase the uptake of divalent metal ions from wastewater samples, including Cd^{+2}, Hg^{+2}, and Pb^{+2}.The synthesized nanocomposite exhibited exceptional divalent metal cation removal, attributed to its porous structure and abundance of reactive groups, as shown by FTIR and FE-SEM investigations. The attachment of L-ascorbic acid to polyaniline was facilitated by the oxime bond (–NH–O–). MnO_2 granules were confirmed to be clustered over the surface of polyaniline by both the HRTEM and FESEM techniques, increasing the surface area available for metal ion adsorption. The kinetics of adsorption had been explained using pseudo-second-order model. The research showed that during the adsorption process, the ions Cd^{+2}, Hg^{+2}, and Pb^{+2} might have experienced both physical sorption and chemisorption simultaneously. The results demonstrated that the maximal adsorption capacities for Cd^{+2}, Hg^{+2}, and Pb^{+2}were 219.6, 215.0, and 223.5 $mg.g^{-1}$, respectively. Thermodynamic study revealed that the intake of Cd^{+2}, Hg^{+2}, and $Pb^{+2}$was endothermic and spontaneous occurred on its by itself. As a result, it has been found thatLPANI@MnO_2nanocomposite was a superior adsorbent for the removal of heavy metals. **Seventh Chapter** is about the detailed future scope of the thesis research work for further exploration. The present thesis thus successfully reports the development of new bio based Nanoadsorbents such as *Vernonia cinerea* and *Tricholepis glaberrima* mediated nickel nanoparticles, WO_3@BLP bionanocomposite, and LPANI@MnO_2nanocomposite for the removal of organic contaminants and heavy metal ions from aqueous solution. The research work has contributed to the area for the development of new nanoadsorbents for wastewater treatment which will provide insight and assist further related developmental studies.