ABSTRACT

The existence of hazardous pollutants in water particularly arsenic (As), chromium (Cr), and organic dye is a global concern due to their harmful impacts on the biosphere. In this context, several physicochemical and biological processes have been widely investigated to remove the targeted pollutants. Among them, the adsorption process offers significant advantages due to its ease of operation, high selectivity, cost-effectiveness, and reusable property. From this perceptive, nanostructured hybrid materials have been recognized to be more beneficial over traditional adsorbents owing to the availability of high surface area and active sites. Conducting polymers like polyaniline, (PANI), polypyrrole (PPY), and their composites have also been extensively used in water treatment due to their high adsorption efficiency, presence of nitrogen-containing amine and imine functional groups, interesting doping/de-doping chemistry, and excellent environmental stability. Considering this, the present study is focused on the developments of nanomaterials acting as effective adsorbents in the removal of arsenic, chromium, and organic dye from contaminated water.

In view of this, objective 1 includes the synthesis of polyaniline hollow microsphere (PNHM)/Fe_3O_4 magnetic nanocomposites by a novel strategy and their characterization. Our investigations have shown ~98–99% removal of As(III) and As(V) in the presence of PNHM/Fe_3O_4–40 following pseudo-second-order kinetics and equilibrium isotherm data fitting with Freundlich isotherm. The maximum adsorption capacity (Q_{max}) of As(III) and As(V) corresponds to ~28 mg g^{-1} and 83 mg g^{-1}, respectively.

Objective 2 demonstrated the fabrication of PNHM/MnO_2/Fe_3O_4 composites by in-situ deposition of MnO_2 and Fe_3O_4 nanoparticles on the surface of PNHM and study its absorption behavior towards the removal of toxic methyl green (MG) and congo red (CR) dyes. Room temperature batch adsorption study showed about 88% and 98% adsorption efficiencies for MG and CR dyes, respectively, at an optimum 1 g L^{-1} dose of PNHM/MnO_2/Fe_3O_4 at pH ~6.75.

In objective 3, polypyrrole-polyaniline coated on rice husk ash (PPY–PANI@RHA) has been fabricated by in-situ polymerization and used as an adsorbent in the removal of

hexavalent chromium (Cr(VI)) from the aqueous solution. Our findings show ~98% of Cr(VI) removal at room temperature (303±3K) under optimum conditions of adsorbent dose (0.8 g L^{-1}), adsorbate concentration (50 mg L^{-1}), solution pH (~2), and contact time (300 min). The adsorption of Cr(VI) followed the Elovich kinetics and was better described by the Freundlich isotherm with the Q_{max} value of ~769 mg g^{-1}.

A plausible adsorption mechanism based on x-ray photoelectron spectroscopy analysis has been proposed for the adsorption of arsenic, dye, and chromium. Thermodynamic studies established the endothermic and spontaneous nature of the respective adsorption processes. The investigations with real field water have also shown better performance in the removal of these various pollutants. All these findings clearly established PNHM/Fe_3O_4–40, PNHM/MnO_2/Fe_3O_4, and PPY–PANI@RHA composites to be very promising adsorbents in the removal of targeted contaminants.

Keywords: Water, Rice husk ash, Polyaniline, Polypyrrole, Fe_3O_4, MnO_2, As, Dye, Cr, Adsorption.