Abstract

The present research work has been undertaken to develop and analyze the performance of a semifluidized bed as a reactor for adsorptive removal of various heavy metals and organic pollutants along with its application in real steel plant effluents treatment operation. A lab scale semifluidized bed has been developed and it's hydrodynamic parameters like minimum fluidization velocity, semifluidization velocity, packed bed formation tendency, bed pressure drops etc. have been estimated with various operating conditions. The study reveals that, the low-density particles significantly reduced the minimum fluidization velocity ranging from 0.004 - 0.01 m/s, and minimum semifluidization velocity of 0.032 – 0.006 m/s. Maximum pressure of the system was found to be 5-6 kPa which is significantly lower value. In order to replace the bed materials as bio adsorbents, novel composite adsorbent was prepared from agricultural solid biomass-based biochar and Na-alginate and used in treatment operation. The biochar was prepared from pine cone and sugarcane bagasse precursor. Both the adsorbents have high surface properties in terms of specific surface area, pore size, functional groups, surface morphology and total carbon contents which are important for adsorptive surface reaction The BET surface area of both sugarcane bagasse based biochar and its composites materials were 391.42 and 200.14 m^2/g respectively, whereas for pine cone based biochar and its composite were 144.94 and 163.87 m^2/g respectively. Experimental batch adsorptive removal of aqueous phase inorganics/organics by biochar and composite adsorbents materials were carried out to identify and optimize various process parameters and their effects on adsorption mechanism. Kinetic experiments confirmed that the batch adsorption reaction was fast and equilibrium was attended within 3 hours' time. The pseudo-first-order and pseudo-second-order kinetic models were fit to the experimental data and various kinetic model parameters were determined by both linear and non-linear regression methods. Weber-Morris diffusion model confirmed the nature of adsorption and some other studies

like thermodynamic, activation energy of the system showed the type of adsorption. Later these adsorbent materials are used as the solid phase of the semifluidized bed to evaluate the bed performance. Real steel plant effluents were collected from DSP, SAIL, W.B. and its was treated through the same semi-fluidized bed reactor as case study. The equilibrium time for the system is 240-300 minutes which is satisfactorily lower with compared to other systems like the packed bed or fluidized bed. Maximum capacity for Zn^{2+}, Cu^{2+}, Ni^{2+}, Pb^{2+}, Cd^{2+} MB dye and Phenol for the bed operation were found to be 42.4, 43.27, 46.12 54.4, 36.8 37.5 and 89.35 mg/g respectively. The experimental data were optimized by RSM analysis to find out the optimum operating condition at which the system gives maximum bed efficiency. A real-time dynamic mass transfer model for the novel system was also developed by assuming the system as a PFDR based on solute phase mass balance. Various mass transfer parameters for the system was also obtained from the developed model and accordingly validated with the experimental data.

Keywords: semifluidized bed, wastewater treatment, heavy metal removal, dye removal, phenol removal, steel plant effluent treatment, adsorption, dynamic modeling.