ABSTRACT

Water is very essential part of our life. Nature has gifted this in safe and consumable form. However, with the growth of population, resulting in industrialization, has directly affected the availability as well as purity of water. The fluoride contamination in drinking water is one such detrimental effect. Therefore, in the present work, the investigations were undertaken to resolve the fluoride contamination in wastewater in efficient, simple and economic way by adsorption methodology. The fluoride contaminated wastewater was attempted for adsorptive treatment by metallic oxides like alumina and electric arc furnace slag. The alumina is highly selective to fluoride ions. Its sulfuric acid activation was attempted for enhancement of adsorption efficiency. The physiochemical characterizations indicated the successful activation of alumina. The nonlinear curve fitting of isotherm and kinetic model revealed its Q_{max} of 69.52 mg/g and following of Freundlich isotherm as well as pseudo second order kinetic model. The activation of alumina caused the increment of defluoridation from 63.58% to 96.72%. Besides, the sulfuric acid activated alumina exhibited the potential of regeneration, reusability (4 cycles), economic feasibility and defluoridation (93.44%) of industrial wastewater. The activation of alumina by nitric acid also exhibited better and improved result (97.43%) over unmodified alumina (74.18 %). The amorphous nature with enhanced specific surface area of HNO_3 treated alumina was revealed by XRD and BET analysis. The maximum equilibrium adsorption capacity of 45.75 mg/g and better following of Freundlich isotherm and pseudo second order kinetic model by nitric acid activated alumina was obtained. The potential to treat the industrial wastewater as well as the feature of regeneration and reusability, distinguish the nitric acid treated alumina as one of the promising adsorbent for removal of fluoride. The investigation was carried out to further enhance the fluoride adsorption capacity of sulfuric acid activated alumina by incorporating the oxides of calcium and zirconium. The experimental result asserted the considerable improvement of fluoride capturing tendency of parent alumina. The results of SEM/EDX and XRD analysis exhibited the incorporation of calcium and zirconium oxides on sulfuric acid modified alumina. It resulted in maximum equilibrium adsorption capacity of 216 mg/g. The fluoride adsorption on prepared adsorbent was better fitted to Langmuir isotherm and pseudo second order kinetic model. The prepared tri-oxide adsorbent of calcium, zirconium and aluminium was capable of defluoridation (92%) from industrial wastewater to meet the WHO permissible limit (1.5 mg/L). Attempt was also given to use the waste material from steel industry (i.e., Ferro alloy electric arc furnace slag)

for the defluoridation of fluoride contaminated wastewater, after modification of slag by treatment with applied heat (600 ^{o}C) and sulfuric acid. The mixed oxide nature of ferro-alloy electric furnace slag as well as its heat and acid treatment has further attributed in improved capture of fluoride. It resulted in improved performance of batch (68.98% to 97.42% defluoridation) as well as column (24 to 54 bed volumes treatment). Its experimental data followed the Langmuir isotherm (Q_{max} of 13.43 mg/g at 45 ^{o}C) and pseudo second order kinetic model. In last part of this work, the attempt was given for continuous adsorption of fluoride by using sulfuric acid activated alumina loaded in fixed bed adsorption column. The experimental data of column study exhibited the better fitting to Clark model than that of Thomas, Yoon-Nelson, Yan and BDST model. The performance of column was found to be superior by using sulfuric acid modified alumina than that of parent alumina. The column loaded by H_2SO_4 treated alumina (5g) was capable of defluoridation of industrial wastewater (16.54 mg/L) up to satisfactory extent (% R = 89.76%; t_b = 350 min; t_e = 1037 min).

Keywords: Fluoride removal, Industrial wastewater treatment; Adsorption, Alumina; Ferro alloy electric arc furnace slag, Acid and heat activation; Fixed bed adsorption column