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Adsorption characterization of Pb(II) ions onto iodate doped chitosan composite: equilibrium and kinetic studies

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Iodate doped chitosan (I-CS) composite was synthesized, characterized and used as an adsorbent for adsorption of Pb(II) ions from aqueous solution. The I-CS sorbent was extensively characterized by nitrogen adsorption/desorption to determine the BET surface areas and BJH pore size distribution, elemental analysis, TGA/DSC, FTIR, XRD and SEM. The influences of various chemical parameters *viz.* pH, contact time, dose of adsorbent and initial metal ion concentration on adsorption performance of Pb(II) ions were analyzed. Equilibrium adsorption isotherm and kinetics of adsorption has also been studied. The BET results exhibited decreased porosity and specific surface area of I-CS composite due to the blockage of internal porous cavities by incorporated iodate. The maximum removal of the Pb(II) ions using I-CS adsorbent was observed at optimum pH 6. The dose of adsorbent on the percentage removal of Pb(II) ions also has a prominent effect and maximum Pb(II) ions mitigation found at 0.5 g L^{-1} adsorbent dose with 99% efficiency achieved in 4 h. The adsorption of Pb(II) ions shown applicability of the Langmuir and Freundlich adsorption isotherm suggests the existence of both heterogeneous surface and monolayer coverage of adsorbed molecules. The adsorption process follows pseudo-second-order kinetics. This doped composite adsorbent proved to be an effective for adsorption of Pb(II) ions from aqueous solution.

1. Introduction

The presence and high concentration of many heavy metals like lead, copper, zinc, mercury, chromium, arsenic and cadmium in various water resources can be injurious to the environment and public health. Among all the heavy metal ions, special attention has been given to Pb(II) ions contamination in water. Research on lead has become a prime importance for environmentalist and medical scientists because it has no biological use and highly fatal to human beings and aquatic flora and fauna even in relatively low concentration.[1] It affects the central nervous system, kidneys, liver, gastrointestinal system and it may directly or indirectly cause diseases such as anaemia, encephalopathy, hepatitis and the nephritic syndrome.[2] It is a cumulative poison and carcinogenic even at low concentration.[3] Levels of lead in drinking water, waste water and water used for agricultural and recreational purposes must be reduced to within the maximum allowable concentrations recommended by national and international health authorities such as World Health Organization (WHO). The Current EPA drinking water standard for lead are 0.05 mg L^{-1} but a level of 0.02 mg L^{-1} has been proposed and is under review. According to Indian Standard Institution (ISI) the tolerance limit for discharge of lead into drinking water is 0.05 mg L^{-1} and in land surface waters is 0.1 mg L^{-1}.[4] The wide usage of Pb(II) in various industries has triggered the necessities of developing an efficient method to remove this heavy metal ion from wastewaters. Many conventional methods are known for lead removal from water namely chemical precipitation, membrane separation, ion exchange, coagulation, reverse osmosis, evaporation and adsorption. The adsorption process is found to be effective and economic for wide variety of water pollutant sorption.[5]

Several studies are reported for the removal of heavy metal ions from water. Biosorption of lead(II) from aqueous solutions by non-living algal biomass has been reported.[6] An expensive and effective adsorbent from bagasse fly ash obtained from a sugar industry has been developed for the removal of lead and chromium.[7] Red mud from aluminum industry has been converted into an inexpensive and efficient adsorbent and the authors have used this adsorbent for the removal of lead and chromium from aqueous solution.[4] studies conducted on the kinetic parameter for the removal of lead and chromium from wastewater using activated carbon developed from fertilizer waste material.[8] Recently, adsorptions using biomaterials has been considered as one of the most favorable option in treating wastewater as they are adequate, biodegradable, ecofriendly,

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