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Adsorption of Ammonium Nitrogen from Aqueous Systems Using Chitosan-Bentonite Film Composite

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Abstract

In this work, a novel composite adsorbent based on chitosan and bentonite nanoclay was prepared in the form of thin films and its efficacy for removing ammonium-nitrogen ($NH4^+$-N) from aqueous solution was investigated using batch adsorption experiments. The characterization of both chitosan and chitosan nanocomposite have been done with Thermogravimetric analyser and FTIR spectra. In the adsorption test, the effect of pH, initial concentration, and adsorbent concentration on NH_4^+-N removal was studied. A comparison between as-prepared adsorbent and adsorbent modified with nanoclay was also carried out. The optimum condition for maximum adsorption of ammonia nitrogen from aqueous solution was found to be 15ppm, 0.5g, & 6 for initial concentration, adsorbent concentration and pH respectively. All information obtained gives an indication that the composite can be used as a novel type, fast-responsive and high-capacity sorbent material for $NH4^+$-N removal. As ammonium nitrogen is a good nutrient for plants and chitosan is a biopolymer the exhaust adsorbents can be reused as a fertilizer in agricultural purpose.

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Keywords: Chitosan; Adsorption; Ammonium Nitrogen; Bentonite

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1. Introduction

The disposal of of nitrogen compounds (Nitrate,Nitrite and Ammonia nitrogen) directly from water plants or indirectly from agriculture and leaching from sludge deposited in landfill and fields have resulted in eutrophication of water bodies[1]. It has been widely reported that ammonium nitrogen (NH_4 +-N) is a very common chemical form in aquatic ecosystems and its toxic effect on life is very high[2]. Total removal or at least a significant reduction of NH_4+-N is thus very important prior to disposal into streams, lakes, seas and land surface. Up to now, the main treatment methods to remove/reduce NH_4^+-N involve reverse osmosis, biological nitrification, denitrification, air stripping, chemical treatment, ion-exchange and supercritical water oxidation[3]. The easy operation technology, low energy input & cost, high safety makes the adsorption process a superior solution for ammonium stripping from aqueous systems. The key factor in adsorption technology, is adsorbent. In this work adsorbent material is a biopolymer and adsorbate is a nutrient, so that the exhausted adsorbent can be utilized as a fertilizer agent[5].

From the ancient to the modern time, clay minerals have been used in building materials, earthenware, ceramic products, cement, adsorbent, cosmetics, rubber, paper, paints, etc. The application of particular clay minerals depends on their physical and chemical properties and these properties strongly depend on the structure and composition. The main clay mineral constituents in bentonite are sodium montmorillonite (Na-MMt) and calcium montmorillonite (Ca-MMt)[7]. Bentonite has been used for the removal of various hazardous substances from water or wastewater[4]. High adsorption capacity of bentonite is due to the high charge on their lattice structure and high cation exchange capacity (CEC).In general, normal cation exchange capacity of bentonite is between 40and 130 meq/100.

This work is mainly aimed on the preparation of a biopolymer nanoclay composite and its application for NH4+-N removal from aqueous solution. The characterization of the adsorbents are done with TGA and FTIR spectroscopy. The effects of system parameters, such as pH, values of initial NH4+-N solutions and composition of both adsorbents were also systematically investigated

2.Materials and methods

2.1 Materials

Ammonium Chloride, Sodium hydroxide, Red mercuric Iodide, Potassium Iodide and Bentonite nanoclay was purchased from Sigma Aldrich.. Ammonium chloride was dehydrated at 70^0C prior to use. Commercial grade Chitosan (with a degree of deacetylation of 0.87 and average molecular weight of 3×10^5 was brought from India Sea Food,Kochi. Both chitosan and nanoclay were used as received