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Research Article

Banana Fibers as Sorbent for Removal of Acid Green Dye from Water

Siti Kartina Abdul Karim, Soh Fong Lim, S. N. David Chua, Shanti Faridah Salleh, and Puong Ling Law

Faculty of Engineering, Universiti Malaysia Sarawak, Kota Samarahan 94300, Malaysia

Correspondence should be addressed to Soh Fong Lim; sflim@unimas.my

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In this study, banana fibers extracted from banana leaves, stem, and stalk were used to remove acid green dye from aqueous solution. Three initial concentrations (750, 1000, and 1500 ppm) were chosen to determine the kinetic characteristics of the banana fiber sorbents at 25°C, agitation speed of 200 rpm, and total contact time of 3 hours. The pseudo-first-order, pseudo-second-order, and Dunwald-Wagner kinetic models were applied to the experimental kinetic data. For isotherm study, the batch experiments were performed at 25°C, initial pH 2, agitation speed of 200 rpm, and initial concentrations between 100 and 2000 ppm. The experimental data was fitted to the Langmuir, Freundlich, Dubinin-Radushkevich, and Temkin isotherms. The equilibrium was achieved in less than 90 minutes. The removal of the acid green dye was found to be following closely the pseudo-second-order kinetic model. For equilibrium study, the Freundlich isotherm was found to fit well with adsorption of acid green dye on the banana leaves, stem, and stalk sorbents. The calculated mean free energy of 4–11 J/mol indicated that the sorption process was mostly physical in nature. Experimental results also showed the adsorption performance is greatly affected by the initial solution pH.

1. Introduction

There are various industries that use dyes as colouring agents, such as textile, paint, pharmaceuticals, beauty products, and food. The release of dyes to water is harmful to the aquatic lives as most dyes are complex in nature and of synthetic origin [1]. Moreover, dyes hinder sunlight from entering water and slowing photosynthesis for plants in water [2]. Some of the techniques used to treat dye-containing wastewater are Fenton oxidation, membrane filtration, photodegradation, coagulation-flocculation, biosorption, and adsorption [3–10]. Ease of use, low energy application, and simple operation are some of the advantages of using membrane and coagulation-flocculation [6, 7]. The drawbacks include searching for the right coagulants to maximize the process and membrane fouling. Chemical processes such as oxidation have high efficiency, though the high cost and disposal pose concern on the treatment process [11]. Adsorption is a physical process and has the advantages of simplicity, easy usage, and low energy consumption, similar to membrane and coagulation-flocculation [12]. The use of natural fibers as sorbents is an attractive option, as it is biodegradable and low cost.

The use of natural fibers has been studied over a wide range of water pollutants. The sorbents are used in natural or unmodified form, as activated carbon, as biochar, or modified with other chemicals. Modification of natural fibers as activated carbon has been demonstrated using pineapple waste [2], where the surface area of activated carbon was higher than 500 m^2/g and the maximum adsorption capacity was found to be 288 mg/g for adsorption of methylene blue. Biochar activated with microwave treatment was performed on *P. juliflora* species [13], where the surface area of adsorbents used was between 220 and 330 m^2/g, and the maximum adsorption capacity increased compared to the non-microwave-treated biochar. The use of unmodified and modified-by-calcination rice bran revealed that calcination at high temperature had an adverse effect on the adsorption capacity of the adsorbents [1]. Using methylene blue and