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Research Article

Equilibrium Isotherms, Kinetics, and Thermodynamic Mechanisms of a Novel Polyacrylamide-*Strychnos potatorum* Seed-Derived Activated Carbon Composite for Aqueous Hardness Removal

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Hardness in water is responsible for both residential and industrial problems. Moreover, drinking hard water is suspected as the main cause of chronic kidney disease of unknown etiology (CKDu) in Sri Lanka. The major constituents that are responsible for water hardness are calcium and magnesium ions. In this study, a composite was synthesized using activated carbon of *Strychnos potatorum* seeds (ACSP) and acrylamide to remove hardness in drinking water. The synthesized composite was characterized using Fourier transform infrared-attenuated total reflection (FTIR-ATR) spectroscopy and scanning electron microscope (SEM). According to this study, the process of removal of hardness depends on the contact time, adsorbent dosage, initial contents, and pH of the solution. The adsorption data were well fitted to the Freundlich isotherm and the pseudo-second-order kinetic models. Furthermore, environmental samples collected from Anuradhapura, Sri Lanka, which is well known for water with high hardness, were treated with an adsorbent, and hardness was reduced effectively. Moreover, the adsorption appeared to be spontaneous in nature. Finally, it can be concluded that this adsorbent can be used as an effective hardness-removing agent.

1. Introduction

Hardness in water causes both residential and industrial issues. It produces hard scales in pipes and boilers [1]. Moreover, hard water causes toughening of skin and hair [2]. The major constituents that are responsible for water hardness are Ca and Mg ions. Those constituents originated in water by seepage of sedimentary rocks and runoff from soil [1, 3]. Hardness is expressed as milligrams of calcium carbonate equivalent per liter and that can be classified into four groups: the calcium carbonate concentration of water below 60 mg/L is generally considered as soft; 60–120 mg/L, moderately hard; 120–180 mg/L, hard; and more than 180 mg/L, very hard [3]. Groundwater is the main drinking water source in many countries. Therefore, the consumption of hard water causes serious health problems such as kidney problems, cancer, cardiovascular disorder, and urolithiasis [2].

Due to the problems faced by hardness, many researchers have focused on various methods for the removal of excess hardness from water and wastewater. Various techniques including nanofiltration [1, 4], ion exchange [5, 6], and electro-coagulation [7] have been widely used for the treatment of hardness-enriched water.

However, due to the high cost, applying these methods to remove hardness is not economical [2].Moreover, there are limited studies focused on the removal of hardness by adsorption using low-cost materials [2, 8].

The seeds of the *Strychnos potatorum* trees are nontoxic [9, 10]. And also, due to the water purification ability of seeds, that tree is known as a clearing nut tree. This property is due to the presence of lipids, polyelectrolytes, carbohydrates, and alkaloids with –COOH and free –OH surface groups [10, 11]. Various contaminants in water such as heavy metals, anions, pesticides, and dyes have been