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Adsorption study of heavy metal ions from aqueous solution by nanoparticle of wild herbs

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ABSTRACT

Wild herbs (Equisetum, ***EH*** and Teucrium, ***TH***) were used as environment friendly adsorbents in the present study. This study focuses on the investigation of the adsorption ability of *Co*, *Cd* and *Li* from aqueous solution. The adsorption of heavy metals onto ***EH*** and ***TH*** was dependent on particle size, dose, solution *pH*, contact time, and temperature. Kinetic data were tested using pseudo-first-order and pseudo-second-order kinetic models. The best fit was obtained with the pseudo-second-order kinetic model. Langmuir and Freundlich models have been applied to calculate adsorption data and the thermodynamic parameters; entropy, ΔS°, enthalpy, ΔH°, and the Gibbs free energy, ΔG°; were determined. The results suggests that the adsorption of heavy metals by the wild herbs are endothermic and a spontaneous process. Thus, it was concluded that ***EH*** and ***TH*** are promising adsorbents for the adsorption of heavy metals from aqueous solutions.

Contents

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Introduction

The adsorption of toxic substances resulting from the accumulation of industrial wastes is important and one of the most dangerous challenges facing the environment and society todays. One of the most significant contaminants affecting water resources is heavy metals. These metal ions present a significant risk to animals and humans, because of their high toxicity at both low and high concentrations in soil and water. The search for new techniques to remove these contaminants has involved both chemical and biological methods.

Contaminating materials have become increasingly dangerous with increasing technological development and the need for diverse heavy metals, for example, in ore processing and other modern industries, prompted the organizations concerned with the preservation of the environment to develop restrictions and laws for laboratories and concerning the treatment industrial waste before its release into the environment so that toxic materials do not exceed the allowable limits. Researchers have, thus, devoted efforts to find effective methods for the adsorption of contaminants from waste, but, these processes are often economically expensive; therefore, we must find ways to bypass conventional, high-cost advanced adsorption technologies.

The adsorption of contaminants on the surfaces of solids an effective method for heavy metals remediation. Activated carbon is considered to be an efficient, competitive materials for this task. However, the cost of production is still high; thus, many researchers have begun to search for alternative adsorbents made from local natural materials. Plants are one type of alternative material that can be used to adsorbate heavy metals from water systems and soil.

The current proliferation of technology and development of science have been an enormous boon for humans. They have become dependent on technology and scientific development in various aspects such as daily activities, trade, industry, and work. Heavy metals are structural elements such as lead, zinc, arsenic, cadmium, copper, titanium, cobalt, lithium, aluminum and mercury, and can be in the form of metals or dissolved salts.

These metals are present in the environment in air, water, and soil. For example, factory chimneys release metal oxides into the air, thus transmitting heavy metal pollution to humans, animals and plants. In addition, car exhausts release lead oxides, resulting from the combustion of tetraethyl lead, into the atmosphere and this is one of the most widespread routes to leading contamination of marine organisms with metals, and the transit these contaminants via sea fishing to humans and animals. Furthermore, agricultural soil is one of the most important sources of food polluted by heavy metals, which arises through the irrigation of crops with polluted water or the use of pesticides. In this situation, the metals are transmitted through the vascular system of plants and fruits. Therefore, field crops irrigated with drainage water contaminated by heavy metal ions are one of the most important and most dangerous sources for the entry of poisonous heavy metals into the human body (Al-Qahtani, 2015).

There are many methods adsorption of heavy metals from the environment, both chemical and physical. However, some of these are not economically feasible. Therefore, it is necessary to investigate low-cost effective alternatives. The adsorption of heavy metals by adsorption technology is a good alternative, and it is used in the treatment of wastewater and soil. To compare, the adsorbent substances, the cost, as well as effectiveness, must be considered. Activated carbon is a highly effective adsorption substance of heavy metals from wastewater, but it is soluble under extremely acidic conditions (Wasewar, 2010).

Consequently, there is an increased interest from researchers into low-cost, effective alternatives adsorbents. Many natural materials used in the adsorption of heavy metals (cadmium, copper, chromium, lead, nickel, cobalt, and lithium), have been discovered, such as diplotaxis harra, glebionis coronaria, coffee grounds, banana Peel, fruit and vegetable peels, cactus, rice straw, wheat straw, and salvinia plant (Tounsadi et al., 2015; Seniunait et al., 2014; Hossain et al., 2012; Jain, 2015; Derbe et al., 2015).

The aim of this work is to study the adsorption of heavy metals from water using nanoparticle of abundant wild herbs, which are considered environmentally safe and low-cost. The particle size, dose, solution pH, contact time, and temperature were investigated. Thermodynamic parameters, kinetic, equilibrium and adsorption isotherms were determined to analysis of the adsorption behavior.

Experimental

Materials

All the chemicals used in this study were analytical grade. $Cd(Cl)_2{\cdot}4H_2O$ (98), $Co(Cl)_2{\cdot}6H_2O$ (98), and LiCl (99)%. were purchased from Sigma–Aldrich (Germany).

Preparation of the adsorbents

Equisetum (***EH*** – Fig. 1), the horsetail, is an herbaceous perennial horsetail native that has fertile spore-bearing stems growing from a perennial underground rhizomatous and non-reproductive, and growing throughout arctic and temperate regions of the northern hemisphere. It contains several substances that can be used medicinally (Jump up, 2015).

Teucrium (***TH*** – Fig. 1) is a genus of perennial and annual plants. There are many species, including herbs, shrubs, and sub-shrubs. They are found all over the world but are more common in the Mediterranean climates (Jump up, 2011).

Fig. 1. Equisetum (***EH***) and Teucrium (***TH***).

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