HBRC Journal (2013) 9, 276–282

Housing and Building National Research Center

HBRC Journal

http://ees.elsevier.com/hbrcj

Removal of heavy metals from wastewater using agricultural and industrial wastes as adsorbents

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Received 19 November 2012; accepted 10 March 2013

KEYWORDS

Adsorption;
Adsorbents;
Agricultural wastes;
Industrial waste;
Heavy metals;
Wastewater

Abstract Adsorption processes are being widely used by various researchers for the removal of heavy metals from waste streams and activated carbon has been frequently used as an adsorbent. Despite its extensive use in water and wastewater treatment industries, activated carbon remains an expensive material. In recent years, the need for safe and economical methods for the elimination of heavy metals from contaminated waters has necessitated research interest toward the production of low cost alternatives to commercially available activated carbon. Therefore, there is an urgent need that all possible sources of agro-based inexpensive adsorbents should be explored and their feasibility for the removal of heavy metals should be studied in detail. The objective of this research is to study the utilization possibilities of less expensive adsorbents for the elimination of heavy metals from wastewater. Agricultural and industrial waste by-products such as rice husk and fly ash have be used for the elimination of heavy metals from wastewater for the treatment of the EL-AHLIA Company wastewater for electroplating industries as an actual case study.

Results showed that low cost adsorbents can be fruitfully used for the removal of heavy metals with a concentration range of 20–60 mg/l also, using real wastewater showed that rice husk was effective in the simultaneous removal of Fe, Pb and Ni, where fly ash was effective in the removal of Cd and Cu.

Introduction

Excessive release of heavy metals into the environment due to industrialization and urbanization has posed a great problem worldwide. Unlike organic pollutants, the majority of which are susceptible to biological degradation, heavy metal ions do not degrade into harmless end products [1]. The presence of heavy metal ions is of major concern due to their toxicity to many life forms. Heavy metal contamination exists in aqueous wastes of many industries, such as metal plating, mining operations, tanneries, chloralkali, radiator manufacturing, smelting, alloy industries and storage batteries industries [2].

Treatment processes for heavy metal removal from wastewater include precipitation, membrane filtration, ion exchange, adsorption, and co-precipitation/adsorption. Studies on the treatment of effluent bearing heavy metals have revealed

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Peer review under responsibility of Housing and Building National Research Center.

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http://dx.doi.org/10.1016/j.hbrcj.2013.08.004

Table 1 Low cost adsorbents data.

Low cost adsorbents	Main consistent	Primary source	Physical structure	Chemical characterization (%)	Primary use
Rice husk	Is collected from one of the rice processing factories	Rice	Granular structure insolubility in water, chemical stability, high mechanical strength and its local availability at almost no cost	Cellulose 32.2 Hemicellulose 21.3 Lignin 21.4 Extractives 1.82 Water 8.11	Wastewater treatment
Fly ash	A particulate material produced from the combustion of coal in power plants	Bituminous coal-burning power plant	Spherical shape and pozzolanic properties	SiO_2 57.82 Al_2O_3 22.10 Fe_2O_3 8.33	Building materials, soil amendment and fillers

adsorption to be a highly effective technique for the removal of heavy metals from waste stream and activated carbon has been widely used as an adsorbent [3]. Despite its extensive use in water and wastewater treatment industries, activated carbon remains an expensive material.

In recent years, the need for safe and economical methods for the elimination of heavy metals from contaminated waters has necessitated research Low cost agricultural waste by-products such as sugarcane bagasse [4–8], Rice husk [9–13], sawdust [14–16], coconut husk [17], oil palm shell [18], neem bark [19] etc., for the elimination of heavy metals from wastewater have been investigated by various researchers. Cost is an important parameter for comparing the sorbent materials. However, cost information is seldom reported, and the expense of individual sorbents varies depending on the degree of processing required and local availability. In general, an adsorbent can be termed as a low cost adsorbent if it requires little processing, is abundant in nature, or is a by-product or waste material from another industry. Of course improved sorption capacity may compensate the cost of additional processing [20]. Therefore there is an urgent need that all possible sources of agro-based inexpensive adsorbents should be explored and their feasibility for the removal of heavy metals should be studied in detail. The objective of this study is to contribute in the search for less expensive adsorbents and their utilization possibilities for various agricultural waste by-products, which are in many cases also pollution sources.

Relevant literature

Reviews of some agricultural and industrial adsorbents for the removal of heavy metals from wastewater are presented as follows.

Rice husk

Rice husk is an agricultural waste material generated in rice producing countries, especially in Egypt. The annual world rice production is approximately 500 million metric tons, of which 10–20% is rice husk. Dry rice husk contains 70–85% of organic matter (lignin, cellulose, sugars, etc.) and the remainder consists of silica, which is present in the cellular membrane [21]. In recent years, attention has been focused on the utilization of unmodified or modified rice husk as an adsorbent for the removal of pollutants. Batch studies using tartaric acid modified rice husk as adsorbent have been carried out for the removal of lead and copper and have reported the effects of various parameters such as pH, initial concentration of adsorbate, particle size, temperature etc. It was reported that modified rice husk is a potentially useful material for the removal of Cu and Pb from aqueous solutions [22].

Fly ash

Fly Ash is a naturally-cementations coal combustion by-product. It is extracted by the precipitators in the smokestacks of coal-burning power plants to reduce pollution Since the fly ash disposal problem emerged with the advent of pollution control systems in the 1960's and 1970's, extensive research has been done to understand how it performs in its orthodox