ID: 4009

Valorization of Agricultural Wastes as Low-Cost Adsorbents Towards Efficient Removal of Aqueous Cr(Vi): Parametric, Kinetic, Mechanism and Thermodynamic Study

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ABSTRACT

Extent of heavy metal as hexavalent chromium ions Cr(VI) in natural aqueous environment increases alarmingly owing to improper discharge of waste water from industries. This not only deteriorates the water quality but also potentially threatens human health through the water cycle. Biosorption is preferred over other existing technologies for remediation of aqueous Cr(VI) as it is environmentally benevolent, inexpensive, and logistically easier. Biomaterials like agricultural wastes are found beneficial for Cr(VI) sequestration since these have advantages of no sludge generation, high metal selectivity, efficient regeneration and good recycling ability. In this study, a bio-adsorbent fabricated from agricultural waste: potato peels (PP) was tested for the adsorption of Cr(VI) from simulated wastewater. The physicochemical and textural characterization of the prepared adsorbent was accomplished by using available techniques: *Infrared spectroscopy (IR), X*-ray *diffraction* (XRD), and transmission *electron microscopy (TEM).* We have overviewed the influence of adsorption parameters like pH, time, temperature, initial Cr(VI) concentration, and bio-adsorbent dose for maximum removal. Adsorption kinetics was assessed by fitting the experimental data with the chosen kinetic models. The ability of potato peels to adsorb Cr(VI) ion was determined from the adsorption isotherms plots and the thermodynamic parameters were estimated. Furthermore, a comparison of the results obtained is carried out with commercial powdered activated carbon (CAP). The best removal efficiencies are obtained at pH of order 2 and 12 for CAP and PP respectively, an optimal mass of PP at 0,5 g and 1 g of CAP at 300 rpm. The most appropriate model is Langmuir model and the kinetics are the pseudo second order. The adsorption reaction is a chemisorption according to Elovich's model and the diffusion is extraparticle by Webber and Morris

Keywords: mass transfer, chromate VI, bioadsorbent, kinetic.

1 Introduction

Trivalent chromium Cr(III) is essential in human as well as for plants and animals at trace concentrations, the hexavalent Cr(VI) has been considered more hazardous to public health due to its mutagenic and carcinogenic properties. A wide range of physical and chemical processes is available for the removal of Cr(VI) from waste water, such as electrochemical precipitation, ultrafiltration, ..,etc.[1,2]. Most of these methods suffer from high operational costs. Therefore, it is necessary to develop new treatment processes that are not only effective, but also feasible in terms of cost. Adsorption is one of the most economically favorable and a technically easy method [3]. In the present work, we prepared bioadsorbent from waste which is potato peels and used it to adsorb Cr (VI) ions in a batch system. The effects of different parameters on adsorption were investigated. In order to have better understanding of the adsorption process, some isotherm, kinetic and thermodynamic models were employed. A comparative study was carried out with a commercial powdered activated carbon (CAP).

DOI: 10.21467/abstracts.170 ISBN: 978-81-970666-1-0 (eBook)

2 Experimental

The potato peels were washed in tap water to remove impurities, followed by drying in the open air for 72 hours. Infrared spectra was performed using Thermo Nicolet iS-10 IRTF Spectrometer, piloted by par Omnic 9 software. The surface morphology of the absorbent was visualized with a scanning electron microscope (Quanta 650, Germany). The concentration of Cr(VI) ions was determined spectrophotometrically (Spectromètre UV/Visible Jenway 6300) using diphenylcarbazide as the complexing agent. The different parameters influencing the adsorption were studied: pH: 2 to12, Contact time: 0-60 mn, adsorbents mass (PP and CAP): 0.25 to 1.5 g, initial concentration of chromium solution: 10, 20, 30 mg/l and temperature: 30 to 60°C. The adsorption isotherm data were treated according to Langmuir and Freundlich equations. The models used for study of kinetic of adsorption are: pseudo first order etablished by Lagregen, pseudo second order, Webber and Morris, Boyd and Elovich. The thermodynamic parameters of adsorption reaction as Gibbs free energy of adsorption (ΔG°), entropy (ΔS°) and enthalpy (ΔH°) were calculated.

3 Results and Discussion

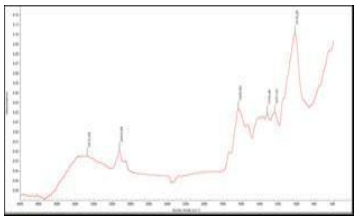

Figure1: *IRTF spectrum of PP*

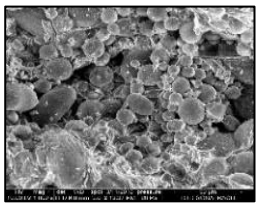

Figure2: *MEB photomicrography of PP*

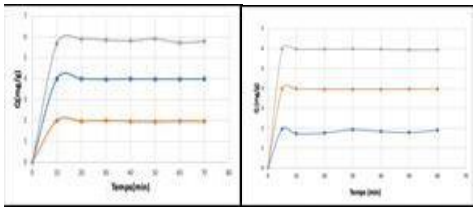

Figure3: *Influence of initial concentration of chromium ion*

Table I. Constant values of Langmuir models for PP adsorbent

	K_1 (l/mg)	q_{max} (mg/g)	R^2
Type I	0,0027	13,7835	0,9827
Type II	0,0034	16,0179	0,9988
Type III	1,5723	14,9749	0,9766
Type IV	1,1419	15,6657	0,9893
Type V	1,8920	13,9545	0,9827

4 Conclusions

Chromium VI adsorption on potato peels (PP) and commercial adsorbent (CAP) follows Langmuir isotherm The pseudo second order model is better suited for modeling the kinetics with a coefficient of determination equal to 0.9993 and 0.9991 for the PP and the CAP respectively and the process of adsorption reaction is chemisorption according to the Elovich model. The Weber and Morris model shows that the diffusion is extraparticle and the Boyd model confirms this. The nature of adsorption process is exothermic and spontaneous for Cr(VI)-PP and endothermic and spontaneous for Cr(VI)-CAP. The results obtained from this study suggest that the adsorbent prepared from plant biomass could be an interesting low-cost adsorbent to remove chromium

5 Acknowledgements

The authors thankfully acknowledge Tazerouti Ahmed- Department of Engineering Process, Faculty of Technology, University of M'Hamed Bougara- Boumerdes, Algeria, for providing all necessary facilities required to carry out this work

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ISBN: 978-81-970666-1-0
Series: AIJR Abstracts
DOI: 10.21467/abstracts.170