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Research Article

A Statistical Modeling and Optimization for Cr(VI) Adsorption from Aqueous Media via Teff Straw-Based Activated Carbon: Isotherm, Kinetics, and Thermodynamic Studies

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Currently, the growth of tannery industries causes a significant volume of waste disposal to the environment due to harmful Cr(VI). Long-time exposure to Cr(VI) imposes serious hazards on all living organisms. Hence, the treatment of tannery waste to remove Cr(VI) is not a choice but mandatory. Therefore, this study focused on the removal of Cr(VI) from the aqueous solutions via a teff (*Eragrostis tef*) straw based-activated carbon (TSAC) which was derived from locally available agricultural solid waste, teff straw (TS). The prepared TSAC was characterized using BET, FTIR, SEM, and XRD. A central composite approach-based RSM analysis was undertaken for statistical modeling and optimization for maximized Cr(VI) removal with respect to four important factors, namely, initial concentration of Cr(VI), the dosage of TSAC, pH, and adsorption time. Optimized values for maximizing adsorption of Cr(VI) (95% of removal) were acquired to be initial Cr(VI) concentration: 87.57 mg/L, TSAC dosage: 2.742 g/100 mL, pH: 2.2, and contact time:109 min. The results from the design of the experiment were also analyzed for the significance of the interaction between the selected process parameters. In addition, the pseudo-second-order kinetic and Langmuir isotherm models were found suitable for describing the adsorption data. The adsorption capacity of Cr(VI) on TSAC was 19.48 mg/g. The observed thermodynamic characteristics reveal that Cr(VI) adsorption on TASC is endothermic in nature. From the results, TSAC had shown a potential Cr(VI) efficiency on optimized process conditions that can be exploited effectively as adsorbent for removal of Cr(VI)-contaminated wastes.

1. Introduction

The rate of contaminated wastewater has kept on increasing intensively as a result of rapid urbanization and industrialization. According to the report by UNWWAP in 2017 [1], approximately 80% of wastewater is discharged to water sources without being properly treated. Due to several toxic contaminants and their harshness, the natural environment is getting affected. This issue should be concerned seriously specifically to third-world countries like Ethiopia since they dispose of approximately 90% of contaminated wastewater to the landfill without being treated properly [1, 2]. Recently, the fast growth of industrialization causes a large amount of heavy metal-laden disposal to the environment which is highly toxic, mutagenic, and oncogenic. Among the different industries, leather industries release a significant volume of Cr(VI)-laden wastewater [3].

Tanning is one of the most important and critical processes in which durable leathers are formed. It produces fewer vulnerabilities to decompose [2]. This process