Chemically modified palm kernel shell biochar for the removal of heavy metals from aqueous solution

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Abstract. Heavy metals eradication from water is a complicated subject, therefore a viable, resilient, and green technology is imperative. Heavy metal removal can be accomplished through easy access, economical, and efficient sorbents derived from agricultural waste. In the current study, palm kernel shell (PKS) waste was converted into biochar (PKSC) via pyrolysis. Chemical modification was performed on PKSC via acid-base treatment to refine its adsorption properties. Batch experiments were conducted to study the efficiency of PKSC and acid-base treated PKSC (MPKSC) for removal of Cr(IV), Ni(II) and Cu(II). The surface area was increased from 112.934 m^2/g to 149.670 m^2/g by acid-based treatment. Batch adsorption study showed that the MPKSC afforded high removal efficiency for Cu (99.29%), Ni (96.77%) and Cr (42.97%). The Cr(IV) and Ni(II) adsorption by PKSC, as well as Cr(IV), Ni(II) and Cu(II) adsorption by MPKSC were best represented by Freundlich isotherm. However, Cu(II) adsorption by PKSC can explained by using Langmuir isotherm. All studied heavy metals fitted the pseudo-second-order kinetic.

1. Introduction

The growth in industrialization and urbanization has led to various environmental issues, including pollution due to heavy metals. Owing to its toxicity to humans, wildlife, and plants, heavy metal contamination is one of the environmental and health issues. Strong metal is poisonous and continues to absorb and induce disease in organisms [1]. Heavy metals are known as inorganic waste that is not biodegradable and persists in the water supply. Electroplating, electronics, batteries, and metal treatment/fabrication are among the main sources of these toxic heavy metals. Electroplating industries generates vast amounts of metal-rich effluents that discharge high concentrations of many hazardous substances, like cyanides, cleaning agents, degreasing solvents, grease, fat, poisonous heavy metals, in particular chromium, nickel, and copper, and surpass the permitted limits [2].

Effective removal of heavy metals from water is crucial for the preservation of drinkable water source. Many techniques have been employed to eliminate or reduce the concentration of heavy metals in wastewater. Adsorption is recognized as one of the best heavy metal removal techniques owing to its functional coherence, low cost, and high performance, when a suitable adsorbent is employed [3], [4]. At the same time, biochar has been applied for many environmental uses, including as adsorbent for heavy metal removal from wastewater. Biochar, a porous carbon-rich material with a large surface area is a product of pyrolysis or carbonization. Many mechanisms are linked to the efficient removal of heavy metals by biochar, including electrostatic interactions, absorption, ion exchange, complexation, and chemisorption [5], [6].