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ORIGINAL ARTICLE

# Intensified Pb(II) adsorption using functionalized KCC-1 synthesized from rice husk ash in batch and column adsorption studies

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## Abstract

An attempt to investigate the feasibility of 3-aminopropyltriethoxysilane (3-APTES)-functionalized KCC-1 ($NH_2$/KCC-1) prepared from rice husk ash (RHA) for Pb(II) removal was executed. An effective functionalization of fibrous silica nanospheres (KCC-1) by $NH_3$ was confirmed by FTIR analysis. The optimized condition of Pb(II) adsorption in the batch system was at an initial Pb(II) concentration ($X_1$) of 307 mg/L, adsorbent dosage ($X_2$) of 2.43 g/L, and time ($X_3$) of 114 min, with the Pb(II) removal ($Y$) of 90.1% (predicted) and 91.2% (actual). $NH_2$/KCC-1 can be regenerated by nitric acid (0.1 M) with insignificant decline of Pb(II) removal percentage (adsorption = 91.2–67.3%, desorption = 77.7–51.9%) during 5 cycles adsorption–desorption study. The examination of column adsorption study at a varying flow rate (1–3 mL/min) and bed height (10–20 cm) showed a good performance at a lower flow rate and higher bed height. Both Adam–Bohalt model and Thomas model displayed a good correlation with experimental data. However, Thomas model was more suitable due to the high correlation coefficient, $R^2$ = 0.91–0.99. This study revealed the intensified Pb(II) adsorption using $NH_2$/KCC-1 synthesized from RHA in batch and column adsorption studies.


**Keywords** KCC-1 · Fibrous silica nanospheres · Pb(II) adsorption · Rice husk ash · Optimization

## Introduction

Nowadays, due to the fast evolution of industrial development, environmental pollution has become one of the major concerns. The growth of the paper, batteries, tanneries, petrochemical, and fertilizer industries has directly or indirectly discharged heavy metals into the environment (Khan et al. 2021). Heavy metals are carcinogenic and have the potential to accumulate in living beings (Rehman et al. 2021).

Lead (Pb(II)) is known as the most poisonous and carcinogenic. Exposure to Pb(II) through inhalation and ingestion of food or water will cause severe diseases and permanent trauma to human's neurological system, deadly brain, kidney, and circulatory system (Rahman et al. 2019). Besides, Pb(II) can also affect aquatic life in physiology, biochemistry, behavior, and reproduction (Petitjean et al. 2019; El-Gendy et al. 2021). However, the maximum permissive limit (MPL) of Pb(II) concentration is only less than 0.5 µg/g, as itemized by World Health Organization (Loghmani et al. 2022). Therefore, the amount of Pb(II) emitted into the environment must be reduced because of its toxicity, even at modest levels of contamination.

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