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Heavy Metal Immobilisation in Soil Using a Novel Biopolymer Based on Xanthan Gum

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Abstract

Contact time, starting concentration, and pH change were used to demonstrate how Cd, Cu, Pb, and Zn sorption reactions occurred when a biopolymer based on xanthan gum was present. The biopolymer has three major functional groups and has a negative surface charge in the pH range of 1-8.5. (i.e., OH, C-H, and C double bond C bonds). The biopolymer's concentrations of Cd, Cu, Pb, and Zn reached equilibrium after 10 min, and a pseudo-second-order kinetic process ensued. Cd, Cu, Pb, and Zn each had maximal sorption capacities of 16.0 mg/g, 8.5 mg/g, 38.3 mg/L, and 7.2 mg/L, respectively. It was discovered that the Langmuir sorption isotherm was more suitable than the Freundlich model. Additionally, HCl and NaH2PO4 extraction were used to evaluate the immobilisation of heavy metals in the soil that had been amended with biopolymers. Cu was found to be immobilised in soil between 20% and 90% of the time, and the immobilisation rate rose with the biopolymer mixing ratios. According to this study, Cd, Cu, Pb, and Zn may be removed from solutions using a biopolymer, and the biopolymer could also be used as an addition to immobilise heavy metals in soil.

Keywords: Xanthan; Biopolymer; Heavy metal

Introduction

Due to recent climate change phenomena such excessive rain, drought, and river floods, physical and chemical soil erosion has taken place in many different locations. Due to soil erosion processes, which may result in heavy metal pollution of the water and soil in wide areas, geochemical dispersion of heavy metals was able to occur. Water resource protection and sanitation may be at risk from heavy metal water contamination. Soil and water management must be done properly if resources are to be secure. For the removal of heavy metals from the solution, electrochemical reaction, ion exchange, and precipitation might be used. The sorption process has been the subject of numerous investigations. Additionally, biological adsorbents have been suggested in earlier studies because they are environmentally beneficial and have low running costs.

Under aerobic conditions, the bacterial species Xanthomonas campestris and Pseudomonas aeruginosa produce xanthan gum, a polysaccharide biopolymer. Xanthan gum has a molecular make-up of two glucoses, two mannoses, and one glucuronic acid. Because xanthan gum is a viscous biopolymer, Chaney, Swift, and Chang et al. recommended using it as a supplement to increase soil strength. This work, however, focuses on geochemical methods to clarify xanthan gum applications based on its structure and surface characteristics. According to earlier research, xanthan gum has a wide pH range, is stable, and contains a molecular structure that reacts with cations. The ability of xanthan to bind to diverse cations utilising conductivity variation was reported by Bergmann et al [1, 2, 3, 4].

Xanthan gum-based biopolymer characteristics

The molecular structure of the biopolymer was determined using the FTIR spectra in the 4000-400 cm1 region. In the investigated biopolymer, three polysaccharides were found at 3293.8, 2931.3, and 1637.7 cm1. The signals between 3500 and 3000 cm1 are caused by the biopolymer's xanthan gum's OH stretching vibration.

The peak was confirmed to be at 2931 cm1, and the peaks in the range of 3000-2800 cm1 implied C-H stretching vibration in xanthan gum [5].

An anionic polymer called xanthan gum (C35H49O29) is created when glucose or sucrose are fermented. Using attenuated total reflection Fourier-transform infrared spectroscopy, surface functional groups were examined to determine the biopolymer's surface characteristics (ATR-FTIR, PerkinElmer Frontier, USA). The wavelength ranges used for data gathering were 4000-400 cm1. Therefore, the goal of this study was to characterise the qualities of xanthan gum-based biopolymers as well as their binding properties to Cd, Cu, Pb, and Zn. Batch tests with heavy metal and biopolymer solutions were conducted at varying contact times, starting concentrations, and pH adjustments. Additionally, the immobilisation of heavy metals in the biopolymer-added soil was assessed under several extraction scenarios [6, 7, 8].

Conclusion

Cd, Cu, Pb, and Zn were successfully immobilised in the soil by sorption using the investigated biopolymers. A reaction between a 1.5 mM solution of Cd, Cu, Pb, and Zn and the biopolymer was conducted to ascertain the sorption equilibrium time. All studies had quick sorption within 10 min, and after equilibrium, the sorbed Cd, Cu, Pb, and Zn concentrations on the biopolymer reached constant levels. The Cd, Cu, Pb, and Zn sorption equilibrium concentrations. [9, 10].

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Conflict of Interest

The authors affirm that they have no known financial or interpersonal conflicts that would have appeared to have an impact on the research presented in this study.

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