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Comparative study of ^{110m}Ag(I) removal from aqueous media by humic substances

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Abstract
In this study, humic substances—dry cowdung powder and humic acid were used for the removal of precious metal ion Ag(I) from aqueous solution. The effect of process parameters such as contact time, adsorbent dose, pH, and metal ion concentration on the adsorption process was estimated. These novel sorbents exhibited high percentage removal of Ag(I) as 95% and 77%, with a biosorption capacity of 19.0 mg g^{-1} and 3.88 mg g^{-1} for dry cowdung powder and humic acid respectively. High uptake percentages along with thermodynamic and kinetic calculations prove this process to be economical, practicable and the most eco-friendly amongst the available techniques.

Keywords Silver · Biosorption · Dry cowdung powder · Humic acid

Introduction

Indiscriminate pollution of water bodies have been ever growing since the industrial age. Untreated discharge of industrial effluents is the main cause of heavy metal contamination. Cases like the Minamata disease [1] caused by mercury poisoning in Japan, chronic arsenic poisoning in West Bengal [2], high levels of Cr(VI), Pb(II), Zn(II) and other heavy metal ions in rivers and lakes [3–5], have been causing worldwide concern due to its negative impact on the ecosystems. Besides, these heavy metals are easily incorporated into living beings and continue to have a long-term effect on the body. Some of these metal ions also have an elevated economic value and good reusability. Therefore, it is essential to extract heavy metal ions from wastewaters.

Silver is a very useful raw material in various industries due to its ductility, excellent malleability, electrical and thermal conductivity, photosensitivity and antimicrobial properties [6]. Effluents from these industries contain significant amounts of Ag(I) and due to its toxic effects on living forms, the removal of this metal from wastewaters is an important field of research.

Conventional techniques for the removal of Ag(I) include precipitation, electrolysis, solvent extraction, ion-exchange resins and chelating agents. These techniques require greater energy and chemicals, thereby increasing the time and cost of operation and decreasing feasibility. Our research aims at highlighting environment friendly alternatives like biosorption for the removal and recovery of Ag(I) ions from aqueous media. Biosorption process is one of the most preferred green techniques due to its metabolism-independent, passive binding of metal ions [7] by natural, modified or synthesized materials, including waste biomass.

Literature survey covers the sorbents used for removal of Ag(I) along with other metal ions. This includes the research carried out by Hanzlik et al. [8], where several natural carbonaceous materials like spruce wood, pine bark, cork, peat, fusinite, lignite, bituminous coal and anthracite were used as adsorbents. Other adsorbents have also been investigated by several researchers to remove and recover Ag(I), such as crab shell beads [9], bentonite [6], alfalfa biomass [10], waste coffee grounds [11], coconut shell activated carbon [12], vermiculite [13], and various groups of clays [14]. Also, it is known that humic substances have the ability to complex metal ions and play an important role in their immobilization and remediation. However, the present research aims at a sustainable green technology for this clean-up process.

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