Abstract No: 2025_387

Biosorption kinetics of the transfer of Cd(II) ions from aqueous solution on powdered *Dillenia suffruticosa*

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Cadmium is a toxic heavy metal that is extensively present in the environment, contributing to water pollution. Sources such as mining activities and cadmium-containing fertilizers lead to its accumulation in the environment, causing severe human health issues, including renal dysfunction, hypertension, and lung damage. Therefore, developing cost-effective and sustainable methods for its removal is essential. This research explores the novel application of raw, unmodified *Dillenia suffruticosa* as a competitive, low-cost plant-based biosorbent for the targeted removal of Cd(II) ions from aqueous systems. The study focuses on optimizing experimental parameters, performing kinetics analysis, and investigating intra-particle diffusion mechanisms. Under optimal conditions, specifically 0.50 g dosage, 300-500 µm particle size, 60 min shaking, 30 min settling, and ambient pH of 7.35, the process achieves a removal efficiency of over 94% with a *qmax* of 573 mg kg^{-1}. Fourier-transform infrared spectroscopy indicates that the biosorbent contains organic functional groups, such as carbonyl, hydroxyl, and carboxyl, which promote the binding of Cd(II) during the adsorption process. In contrast, X-ray fluorescence spectroscopy confirms the transfer of Cd(II) ions onto the biosorbent surface. Kinetics studies performed by varying the initial pH and Cd(II) concentration show that the adsorption process is best fitted to the pseudo-second order model. Linear plots constructed according to the Weber-Morris intra-particle diffusion model do not pass through the origin, indicating that intra-particle diffusion is not the sole rate-limiting step, and instead, the overall adsorption rate would be controlled by both film diffusion and boundary layer effect. Furthermore, it is observed that an increase in the initial Cd(II) concentration and the solution pH enhances adsorption characteristics, leading to higher adsorption capacities (*qt*). These results demonstrate that *Dillenia suffruticosa* dry powder is a highly effective and environmentally friendly alternative for the treatment of water contaminated with Cd(II).

Keywords:

Biosorbent, *Dillenia suffruticosa*, kinetic, pollutants