Physicochemical Characterisation and Adsorption Isotherm and Kinetic Study of *Revotropix Paulownia* Biochar in Copper (II) ion Removal in Wastewater

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Purpose of Investigation

Due to urbanisation, domestic and industrial processes discharged excessive heavy metals in rivers, seas causing heavy metal pollution in water. Out of all the heavy metals, copper(II), Cu^{2+} ions pose a large impact to humans and environment as it threatens our health such as causing liver, kidney and respiration damage. *Revotropix Paulownia* biochar (PB), an adsorbent derived from *Revotropix Paulownia* sawdust, which is a waste product, is found to be a potential low-cost adsorbent to remove Cu^{2+} ions in wastewater. In this study, we studied physicochemical properties, adsorption isotherms and kinetics of PB.

Method of Investigation

Revotropix Paulownia sawdust undergoes pyrolysis to produce PB. After grinding and sieving, a small amount of PB was selected to be analysed by SEM and EDXA to analyse its surface morphology and elemental constituents and remaining PB, which has size that smaller than 300 mircon, was used in adsorption experiments. Two adsorption experiments were conducted using batch adsorption technique. The first experiment was conducted to determine the effect of initial concentration on removal efficiency and adsorption capacity: 2000 mg/L stock solution of Cu^{2+} ion was serial diluted into solutions of 20 different concentrations each with pH 5.5 and an interval of 10 mg/L between each solution. 1 g of PB were added into each solution. All mixtures were agitated on an incubator shaker under temperature of 25 ^{o}C, contact speed of 180 rpm for 24 hours, final concentration of each solution was determined using ICP-OES. Three different isotherm models: Langmuir isotherm model, Freundlich isotherm model and Temkin isotherm model were used to fit the adsorption data obtained. Second experiment was conduct to determine the effect of contact time on removal efficiency, stock solution of 1000 mg/L was diluted into twelve 120 mg/L solutions. The solutions were all kept at pH 6.5 and mixed with 1 g of PB each. All mixtures were agitated on an incubator shaker under temperature of 25 ^{o}C and contact speed of 180 rpm. In the first hour, a solution is taken out every 10 minutes; in the second and third hour a solution is taken out every 30 minutes. The final concentration of each solution was also determined using ICP-OES. The results were applied in the Pseudo-first order kinetic model, Pseudo-second order kinetic model, Elovich kinetic model and Intra-particle diffusion kinetic model. All experiments were carried out in triplicates.

Results of Experiment

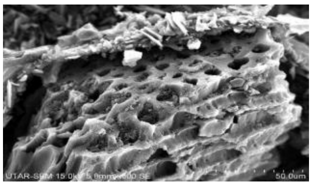


Figure 1

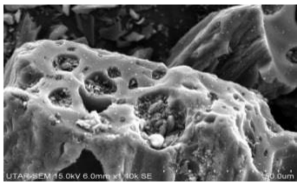
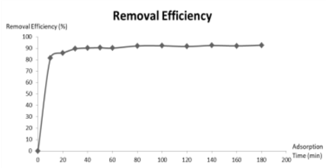


Figure 2

Porous structure on PB surface appeared evident through SEM imaging (Fig. 1 & Fig 2). The porous surface of PB provides a larger surface area for effective adsorption of Cu^{2+} ions in aqueous solution. The results from the EDXA showed higher abundance of carbon (80.00%) and oxygen (16.21%) with traces of sulphur (1.48%), nitrogen (0.062%) and phosphorus (0.024%). The presence of multiple elements in PB could correspond to the existence of functional groups that can aid in adsorption of Cu^{2+}ions.

Graph 1



Graph 2

Graph 1 shows relationship between initial concentration and removal efficiency. Removal efficiency increases sharply and has a maximum efficiency of about 90%. Beyond the optimal removal efficiency, number of available sorption sites becomes the limiting factor.

Graph 2 shows relationship between adsorption time and removal efficiency. The graph shows that the removal efficiency does not changed after 30minutes indicating the equilibrium of adsorption of copper (II) ions in achieved.

The Langmuir isotherm model (R^2=0.9968) and pseudo-second kinetic model (R^2=0.9999) showed the best fit with our adsorption data. The result shows that the adsorption of Cu^{2+} ion by using PB was best described with the monolayer chemisorption. The maximum adsorption capacity of PB is 16.9779 mg/g.

Conclusion

The porous surface, high and rapid adsorption capacity and removal efficiency proves PB's suitability as an effective low-cost adsorbent. The monolayer chemisorption mechanism of PB in Cu^{2+} ion adsorption signifies stronger, irreversible adsorption when applied in wastewater treatment.