PRODUCTION OF BIOCHAR DERIVED FROM SWINE SLUDGE MODIFIED WITH CaO FOR REMOVAL OF METHYLENE BLUE FROM WATER

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Introduction

The expansion of swine production has led to a significant increase in the generation of manure as a by-product, posing ongoing challenges for its proper disposal around the world.

Methylene blue (MB) stands as the most utilized dye in the dyeing of materials such as cotton, wood, and silk (Aaddouz et al., 2023). Mismanagement of effluents containing dyes not only contributes to generate environmental problems but also poses risks to human health. Dye removal generally involves a complex and diverse set of physicochemical and biological processes, and, among the available treatment methods, the adsorption of contaminants using activated carbon has gained considerable interest (Mahajan et. al., 2023).

Materials and methods

Pyrolysis in a tubular oven to obtain the biochar → Modification of the biochar with calcium oxide to obtain BC-CaO → Application of BC-CaO as a methylene blue adsorbent → Adsorption experiments: effect of pH, dosage of adsorbent, kinetics and isotherm

Results and discussion

Figure 1(a) shows the effect of pH on adsorption of methylene blue by the BC-CaO. The pH range from 3 to 11. As the pH was increased from 3 to 11, the adsorption capacity increased from 1.09 to 15.48 mg g^{-1}, respectively. As the pH increases, the concentration of H+ ions in the solution decreases, reducing competition for adsorption. Consequently, the repulsive interactions between methylene blue and H+ ions decrease, favoring the adsorption of methylene blue (Fan et al., 2017). The subsequent experiments were performed at the pH 7.

Figure 1(b) shows the adsorbent dosage on adsorption of methylene blue by the BC-CaO. It is observed that as the adsorbent dosage increased (0.5 to 1.5 g L^{-1}), the removal percentage also increased (53.85 – 77.89 %). However, there is a decrease in adsorption capacity (21.96 – 10.58 mg g^{-1}) with increasing adsorbent dosage, which can be attributed to a greater number of active sites on the adsorbent that remain unsaturated during adsorption of methylene blue (Missau et al., 2022). Therefore, the optimal adsorbent dosage was 0.93 g L^{-1}.

Figure 1(c) shows that there was rapid adsorption in the first 10 minutes, followed by a decrease as equilibrium was reached after 20 minutes.

Equations 1 and 2 describes the pseudo-first order (PFO) and pseudo-second order (PSO) models, respectively. Equations 3, 4 and 5 describes Langmuir, Freundlich, and Liu adsorption isotherm models.

$$q_t = q_1(1 - e^{-k_1 t}) \quad (1)$$

$$q_t = \frac{k_2 q_2^2 t}{(1 + k_2 q_2 t)} \quad (2)$$

$$q_e = \frac{q_{m_L} K_L C_e}{1 + K_L C_e} \quad (3)$$

$$q_e = K_F C_e^{1/n_F} \quad (4)$$

$$q_e = \frac{q_{max}(K_g C_e)^{nL}}{1 + (K_g C_e)^{nL}} \quad (5)$$

Figure 1(d) shows the isotherm curve for the adsorption of methylene blue by the BC-CaO at 303 K. According to the Liu model, the maximum methylene blue adsorption capacity by the BC-CaO was 86.14 mg g^{-1}.

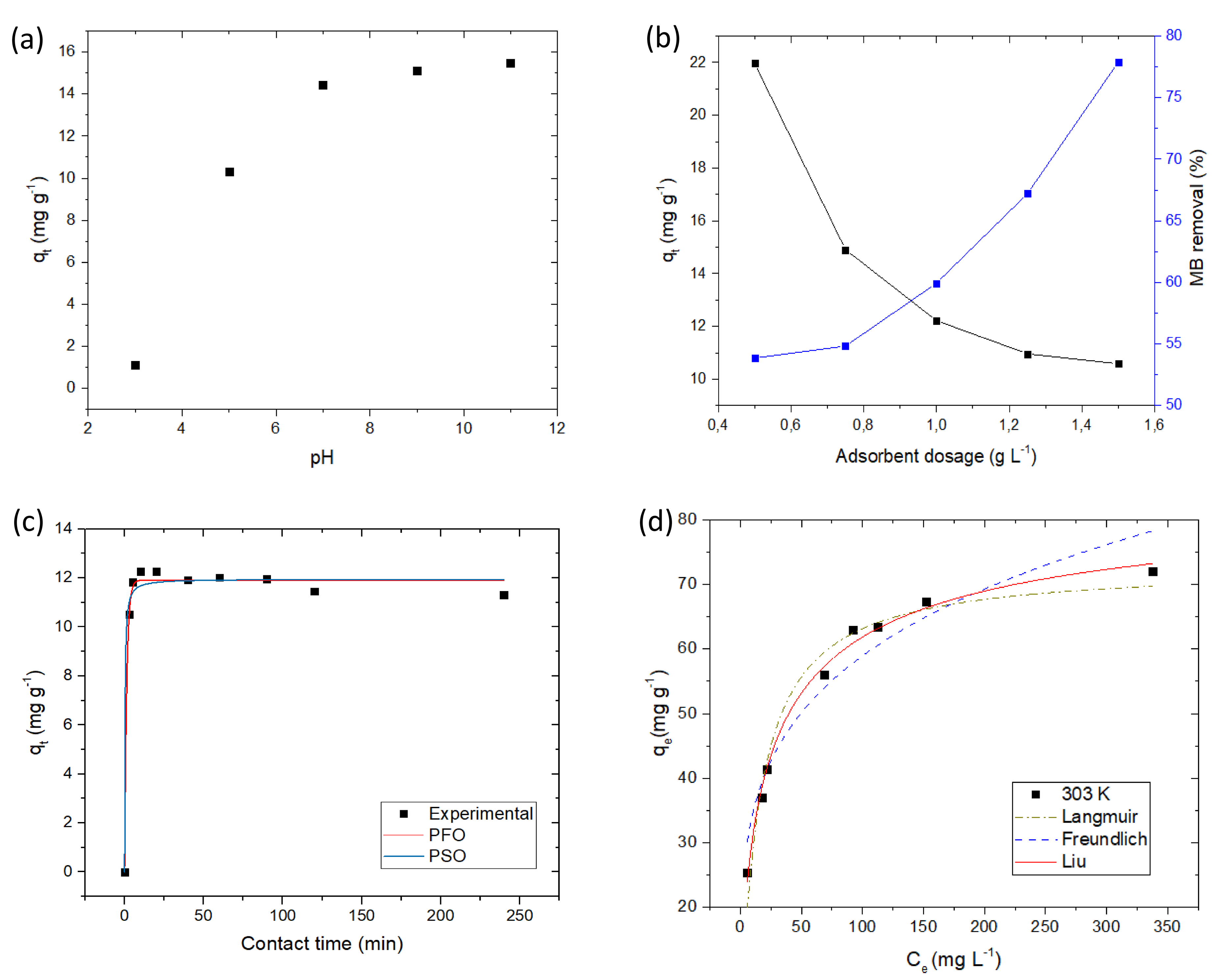

Figure 1. (a) Effect of pH on the adsorption of methylene blue by the BC-CaO; (b) effect adsorbent dosage on the adsorption of methylene blue by the BC-CaO; (c) kinetic curves for the adsorption of methylene blue by BC-CaO and (d) Isotherm curve for the adsorption of methylene blue by BC-CaO.

Conclusions

Activated carbon was successfully produced through the pyrolysis process, followed by modification with calcium oxide. The results presented in this work show the feasibility of applying biochar modified with calcium oxide to remove methylene blue dye from aqueous solutions, as preliminary tests showed that the adsorption capacity of the material increased two times when modifying the biochar with calcium oxide. Furthermore, the production of biochar from swine sludge is a way of adding value to this waste, which is often incorrectly disposed of.

References

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