ASEC 2024 Conference

The 5th International Electronic Conference on Applied Sciences

04–06 December 2024 | Online

MDPI

Optimization of Cu (II)removal from wastewater onto modified cellulose nanocrystals using Box-Benken Design in Response Surface Methodology

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INTRODUCTION & AIM

Background

Heavy metal ions are present in wastewater from various chemical industries, including metallurgy, steel, chemical production, fertilizer, mining, and pulp paper. When copper (II) levels in water exceed safe levels, it can be hazardous to the environment and human health. Copper (II) contamination in wastewater leads to soil erosion affecting the entire food chain. Several technologies, including ion exchange, chemical precipitation, and adsorption, have been developed and used to remove Cu (II) from wastewater based on the reaction mechanism.

Main Objective

The main aim of this study was to remove copper (II) from wastewater using modified cellulose nanocrystals using Box-Benken Design in response surface methodology.

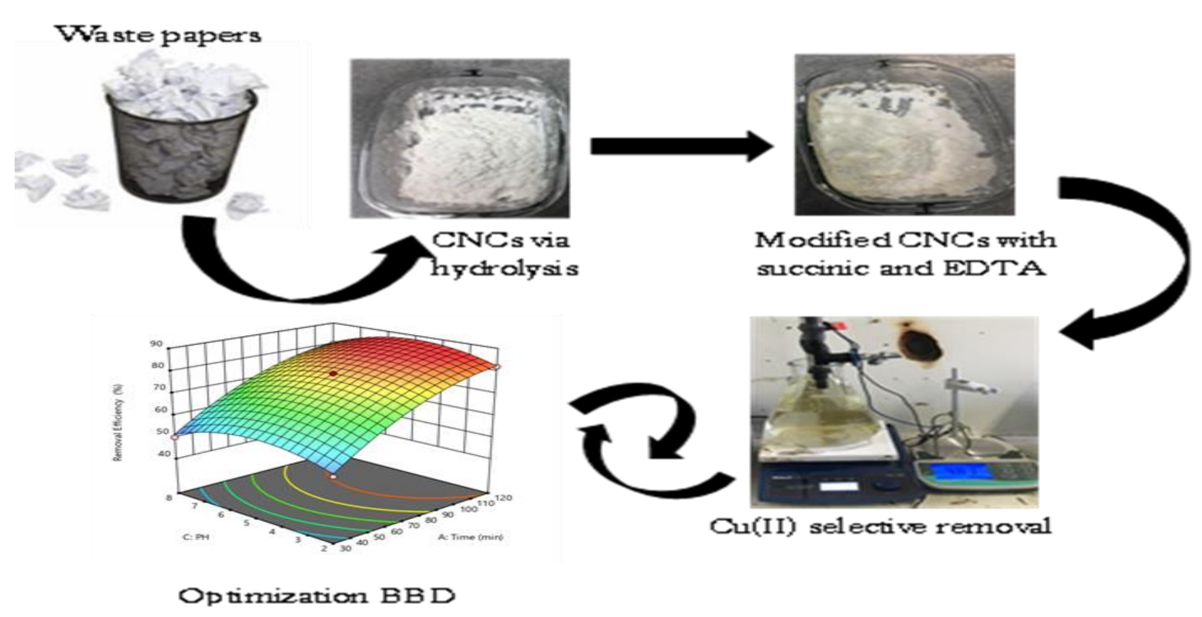

Figure 1 The proposed study (Banza et al., 2023)

METHOD

Materials and Chemicals

Sodium hydroxide (98%), Hydrochloric acid (32%), Acetic acid (99,85%), Ethylenediaminetetraacetic acid (99%), Copper Sulphate (98%), Cellulose nanocrystals from waste paper

Characterisation Techniques: Fourier Transform Infrared Spectroscopy (FTIR)

Modification of Cellulose nanocrystals

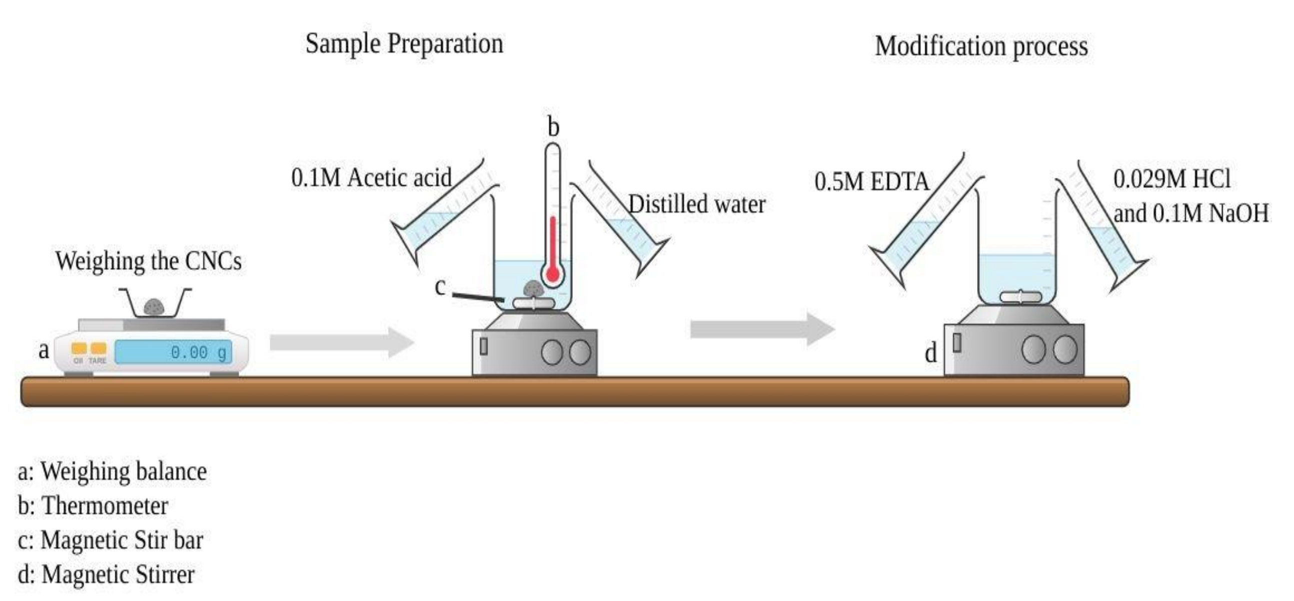

Figure 2 Experimental set-up for modification of cellulose nanocrystals

Batch Adsorption

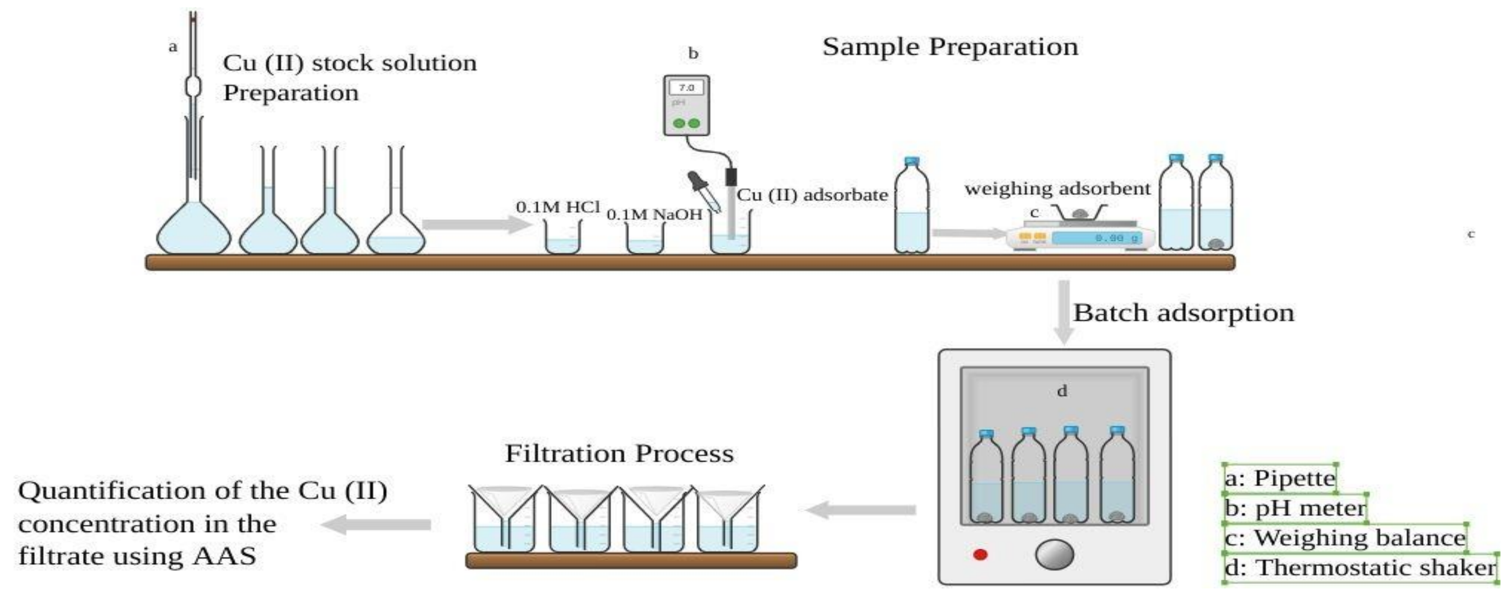

Figure 3 Experimental set-up for adsorption procedure

RESULTS & DISCUSSION

FTIR

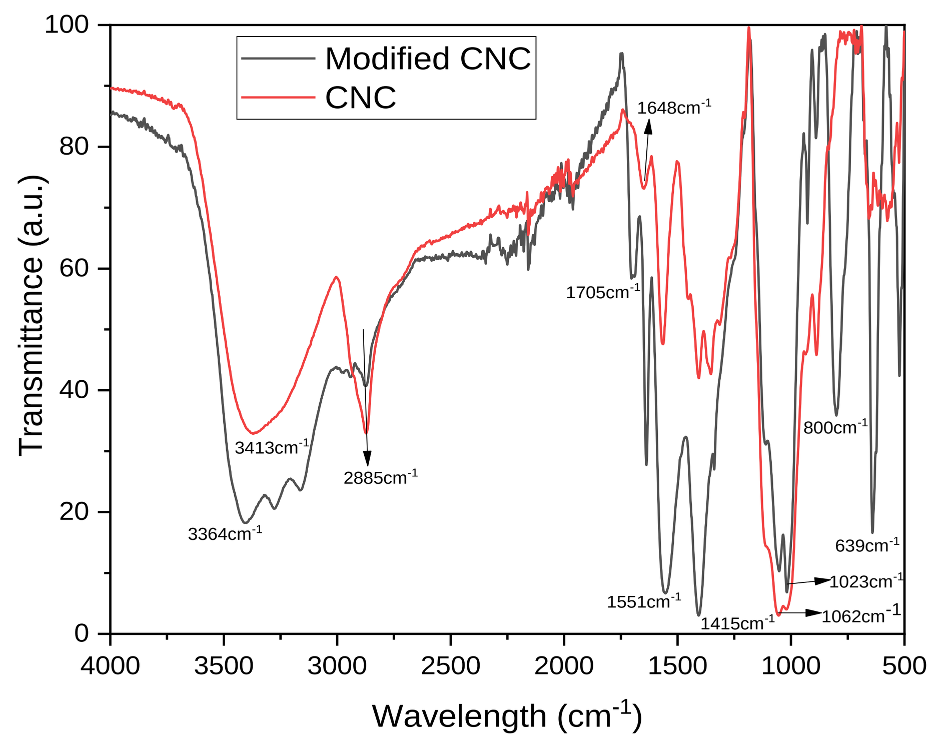

Figure 4 FTIR spectra for Modified CNCs and Unmodified CNC

Response Surface Plots

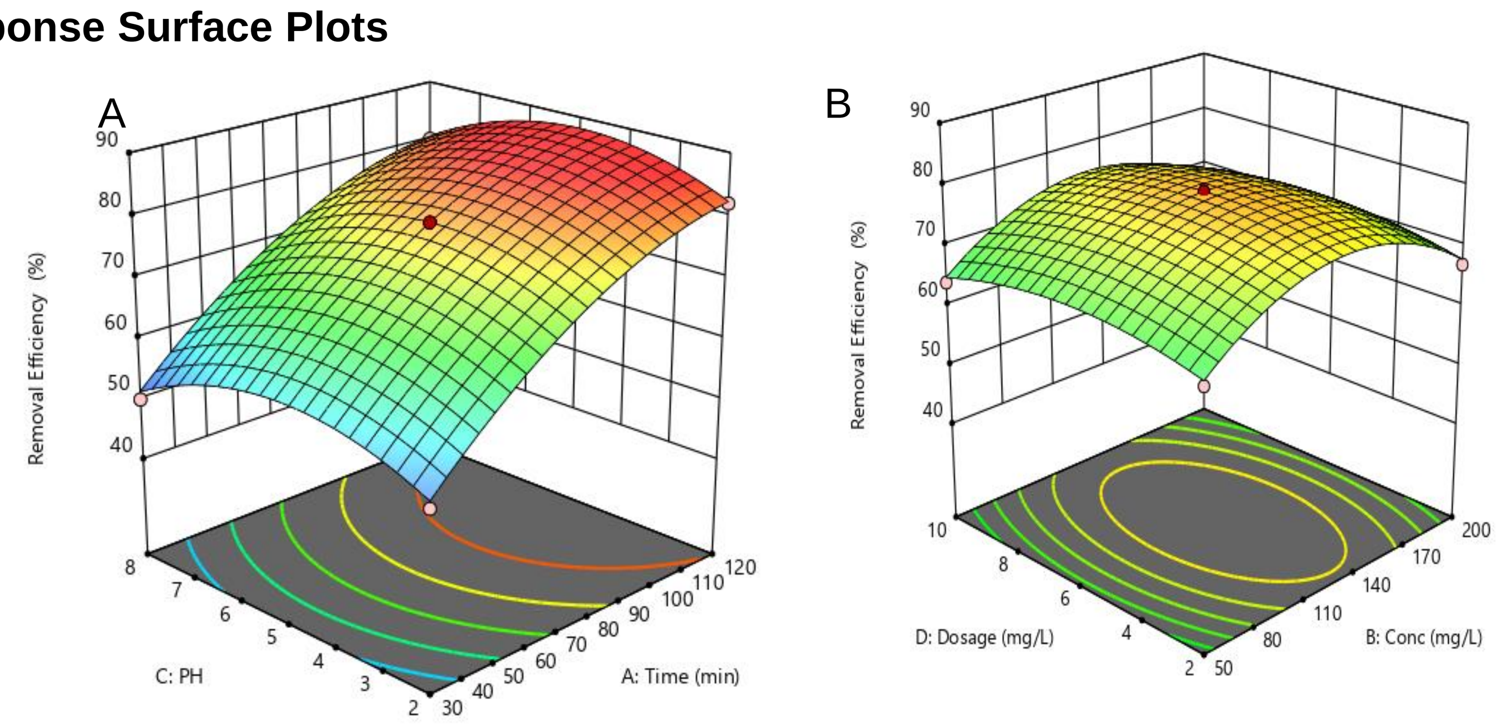

Figure 5 Three-dimensional surface plots of multiple effects for Cu (II) adsorption (A) pH and contact time and (B) dosage and initial concentration.

ANOVA and Optimization Plots

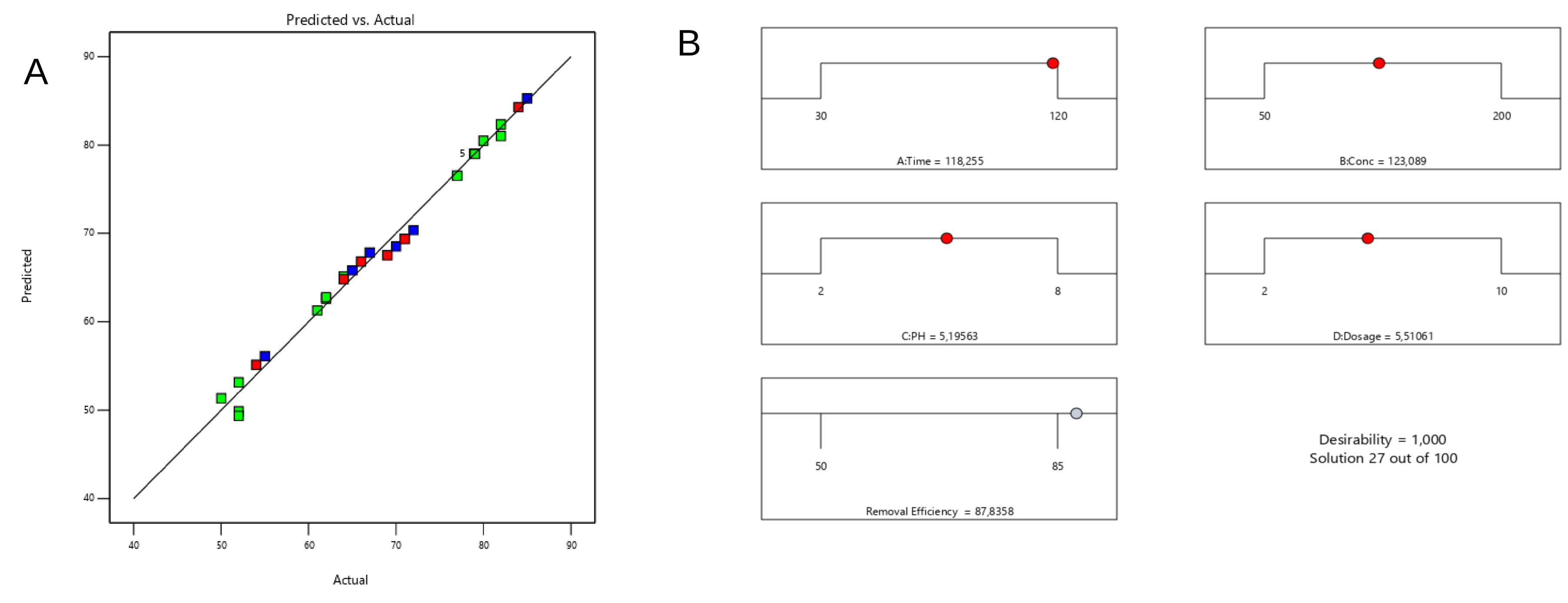

Figure 6 (A) Plot showing the distribution of the predicted vs the actual removal efficiency values. (B) Perturbation plot for Cu (II) adsorption

CONCLUSION

- The CNC's were successfully modified and FTIR confirmed the success of the modification by the presences of the COO- found at peak 1551cm-1
- Solution pH adsorbent dosage, initial concentration, and contact time significantly affect Cu(II) adsorption using CNC's-EDTA
- Optimized removal efficiency Box-Behnken Design in response surface methodology
- Optimal conditions were identified at 118mins of contact, 123mg/L, pH 5, and Dosage 6g/ml with 87,84% as maximum efficiency

FUTURE WORK / REFERENCES

Future work: Precise maintenance of contact time and initial concentration of adsorbate levels is crucial in the future, as they were identified as critical factors influencing the removal efficiency, and small variations can significantly impact the results.

Banza, M., Seodigeng, T. & Rutto, H. Comparison Study of ANFIS, ANN, and RSM and Mechanistic Modeling for Chromium(VI) Removal Using Modified Cellulose Nanocrystals–Sodium Alginate (CNC–Alg). *Arab J Sci Eng* **48**, 16067–16085 (2023). https://doi.org/10.1007/s13369-023-07968-6