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EXPLORATORY DATA ANALYSIS INTERPRETATION OF GREEN CeO_2-BASED PHOTOCATALYSTS DERIVED FROM SEWAGE SLUDGE

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Introduction



(Lin *et al.*, 2023)

Objectives

To evaluate the relationship between material-related variables and operational conditions and the photocatalytic performance of CeO_2-NPs/sludge composites in CV degradation using EDA and Spearman correlation.

Methodology

Green synthesis of CeO_2-NPs

CeO_2-NPs were synthesized via a green route using $Ce(NO_3)_3 \cdot 6H_2O$ and *Ilex paraguariensis* extract as the metal precursor and reducing/stabilizing agent, followed by drying and calcination (Naidi et al., 2021).

Preparation of SS-based composites

Dried and ground SS was impregnated with 2 and 4 wt.% CeO_2-NPs, homogenized, dried, and calcined to obtain photocatalytic composites.

Material characterization

The composites were characterized by SEM–EDS, N_2 physisorption (S_{BET}, V_p, D_p), zeta potential, and pH_{ZCP} analyses.

Photocatalytic experiments

CV degradation was evaluated using different CV concentrations (10 and 20 mg L^{-1}) and catalyst loadings (0.05 and 0.10 g L^{-1}). After 60 min of dark adsorption and 120 min of visible-light irradiation, degradation was monitored by UV–Vis.

Dataset construction and EDA

A structured dataset including S_{BET}, V_p, D_p, zeta potential, pH_{ZCP}, catalyst loading, CV concentration, reaction time, and removal efficiency was compiled in Microsoft Excel and analyzed in Python 3.12.12 using EDA (Langer; Meisen, 2021).

Statistical analysis

Spearman's rank correlation was applied to evaluate monotonic relationships among material-related variables, operational parameters, and photocatalytic performance.

Results and Discussion

The heatmap (Figure 1a) shows the correlations between material-related variables, operational parameters, and CV removal efficiency, while the ranked coefficients (Figure 1b) highlight the variables with the strongest correlations.

Overall, removal efficiency showed positive correlations with S_{BET}, pH_{ZCP}, and reaction time, and negative correlations with D_p, V_p, and dye concentration. These results indicate that both material-related variables and operating conditions are associated with photocatalytic performance.

The density plot shows that most CV removal values were high, indicating good photocatalytic performance under the evaluated conditions. The variation in removal efficiency reflects the combined effects of catalyst composition and experimental conditions.

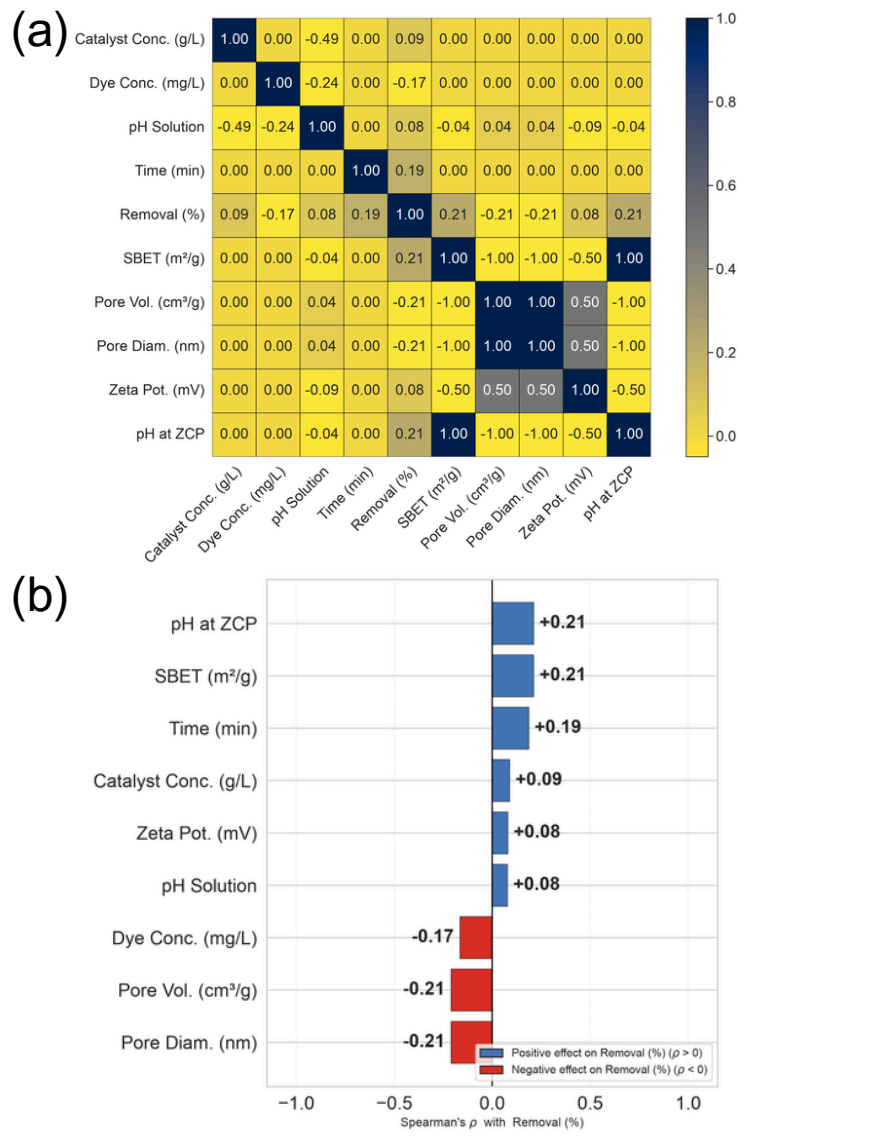


Figure 1. Spearman correlation analysis of the evaluated variables: (a) correlation heatmap and (b) ranked correlation coefficients for CV removal efficiency.

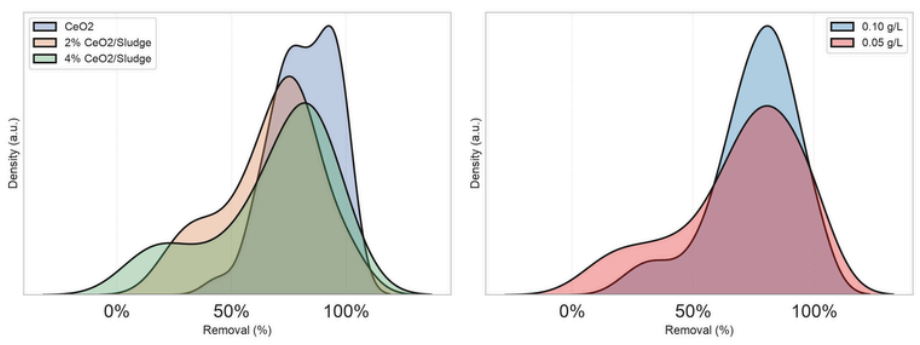
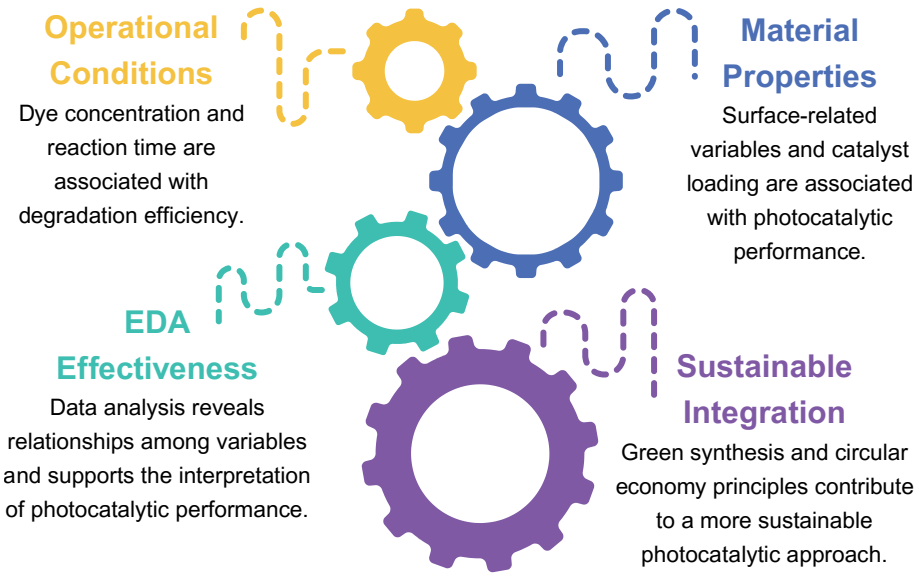


Figure 2. Density distribution of CV removal efficiency under the evaluated experimental conditions.

Conclusions



References and Acknowledgments

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