

# Optimizing Electrochemical Turbidity Removal from Water Using Response Surface Methodology



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**ABSTRACT:** Water turbidity, caused by suspended particulate matter, is a primary indicator of water quality and poses significant challenges for potable water production. This study investigates the optimization of the electrochemical coagulation (EC) process for removing kaolinite-induced turbidity from synthetic wastewater. By applying steel electrodes the impacts of 4 significant operational parameters (applied voltage (V), inter-electrode electrode distance (D), initial solution pH, and initial turbidity concentration (Co)) on turbidity removal efficiency were investigated carefully. The process was modeled and optimized using Response Surface Methodology (RSM) based on a factorial design. The analysis of variance (ANOVA) identified that voltage, pH and their quadratic terms ( $V^2$ ,  $pH^2$ ), whereas the interaction between voltage and distance ( $V \cdot D$ ) as the most significant factors affecting turbidity removal ( $p < 0.05$ ). The fitted quadratic model showed a high value of coefficient of determination ( $R^2 = 98.04\%$ ), indicating good predictive quality of the model. The model also estimated that the maximum turbidity removal of 98.9% was obtained under conditions of applied voltage of 25 V, electrode distance of 2 cm, pH ( $7 \pm 1$ ) and an initial turbidity value of 200 NTU. The results demonstrated that EC is an excellent process for turbidity reduction, and RSM is a powerful tool to optimize complex intersystem, multi-variable interactions associated with it, giving a strong basis for efficient design and operation of water treatment plants.

**KEYWORDS:** Electrocoagulation, Turbidity removal, Response surface methodology, Water treatment, Process optimization, Steel electrodes, Kaolinite.

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## I INTRODUCTION

Driven by the increasing global population, industrialization, and climate change, the demand for clean and safe water is skyrocketing, while water scarcity and contamination are becoming among the most demanding issues of the 21st century (Mawat and Hamdan, 2023). Potable water is not only a basic human right but also a necessary condition for public health, economic development, and environmental sustainability (Boinpally et al., 2023). Among the various sources of water, surface water such as rivers, lakes and reservoirs are used to supply the majority of public water systems throughout the world (Mawat and Hamdan, 2023). Turbidity is a common problem in surface water.

Turbidity is a measure of the cloudiness or haziness of water, caused by the presence of finely divided and suspended matter such as clay, silt, finely divided inorganic and organic matter, soluble colored organic compounds, algae, and other microorganisms (Nair et al., 2014). Turbid water is unsightly and can be unhealthy. Suspended solids interfere with disinfection by shielding pathogens from disinfectants. Suspended solids can promote growth of bacteria, parasites, and viruses. High levels of turbidity support prolific growths of microorganisms that degrade water quality and pose risks to public health (Ghernaout &

Ghernaout, 2011). The removal of turbidity is thus the first and most important step in any water treatment process. Conventional processes for removal of turbidity from water typically involve chemical coagulation, flocculation, sedimentation and filtration.

These techniques involve the addition of chemical coagulants, such as aluminum sulfate (alum) or ferric chloride, to water to remove dirt and other suspended particles. The coagulants neutralize the negative charges on particles and cause the particles to clump together into larger, more easily removable clumps called flocs. Although conventional coagulation/flocculation followed by sedimentation and filtration can be an effective method for the removal of turbidity, these processes have many disadvantages, such as large amount of chemicals must be handled, high costs for transportation and storage of chemicals, large volumes of chemical sludge are generated that must be disposed of, and costs associated with sludge disposal (Phu et al., 2025).

Moreover, the presence of residual coagulant ions (e.g., aluminum) in finished waters may cause health problems including Alzheimer's disease, Parkinson's disease, and muscle disorders. These concerns about coagulation/flocculation process have been driving researchers to explore other efficient and environmentally

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