


Abstract

This study aims to determine treatment efficiency, and evaluate the energy efficacy of integrated electrocoagulation system combined with ozonation, UV/H₂O₂, UV/H₂O₂/O₃, Fenton, and photo-Fenton processes for textile dye-bath effluents' treatment. In addition, reaction kinetics, and comparative study of rate constant (k , min⁻¹) of AOPs were also evaluated to understand the reaction mechanism. A medium-scale advanced physical processes-based treatment plant was studied for its design, and energy-use efficiency to treat dye-bath effluents. Sampling from Inlet, electrocoagulation system, dissolved air flotation system, lamella separator, and reverse osmosis I followed by RO II was carried out. In this regard, the characterization of wastewater quality parameters such as pH, turbidity, salinity, TDS, TSS, electrical conductivity, and COD was analyzed to measure the removal efficiency of each treatment unit in ETP, and AOPs techniques. The electrical energy consumption of all aforementioned processes, reaction kinetics, and comparative study of rate constant (k , min⁻¹) were evaluated to comprehend the reaction mechanisms in oxidative processes. The application of ECS/O₃ resulted in 100 % decolorization and 99.7 % COD removal under optimized operating conditions including ozone flow 300 mg/h, pH 7.1, Temperature 25 °C. ECS/photo-Fenton process resulted in COD and color removal of 95.6 %, and 97 %, respectively. UV/H₂O₂/O₃ process followed by ECS attributed satisfactory results, COD and color removal efficacies were 82.4 %, and 70 %, respectively. The electrical energy per order of the physical treatment plant was 1.7 kWh/m³. EE/O of ECS alone was found 1.58 kWh/m³ for minimum removal of dyes and COD. ECS/O₃ is responsible for complete decolorization but at a very high cost. ECS/photo-Fenton process proved to be the second-best option in terms of treatment and energy consumption. All the R² values of treatment processes were close to 1, which depicts the fitness of the 1st-order kinetic model. Hence, the integrated treatment system of ECS with AOPs appeared to be the most feasible and eco-friendly. That could lead to the treated wastewater for reuse and recycling purposes within the industry.

Keywords: Energy-use Efficiency; Textile Effluent; Advanced Oxidation Processes (AOPs); Ozonation; Photo-Fenton process; Reaction Kinetics; Sustainability  (Ctrl) ▾