Lead Removal From Ex- Mining Pond Water by Electrocoagulation: Kinetics, Isotherm, and Dynamic Studies

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Abstract : Exposure of galena (PbS), tealite (PbSnS2), and other associated minerals during mining activities release lead (Pb) and other heavy metals into the mining water through oxidation and dissolution. Heavy metal pollution has become an environmental challenge. Lead, for instance, can cause toxic effects to human health, including brain damage. Ex-mining pond water was reported to contain lead as high as 69.46 mg/L. Conventional treatment does not easily remove lead from water. A promising and emerging treatment technology for lead removal is the application of the electrocoagulation (EC) process. However, some of the problems associated with EC are systematic reactor design, selection of maximum EC operating parameters, scale-up, among others. This study investigated an EC process for the removal of lead from synthetic ex-mining pond water using a batch reactor and Fe electrodes. The effects of various operating parameters on lead removal efficiency were examined. The results obtained indicated that the maximum removal efficiency of 98.6% was achieved at an initial PH of 9, the current density of 15mA/cm2, electrode spacing of 0.3cm, treatment time of 60 minutes, Liquid Motion of Magnetic Stirring (LM-MS), and electrode arrangement = BP-S. The above experimental data were further modeled and optimized using a 2-Level 4-Factor Full Factorial design, a Response Surface Methodology (RSM). The four factors optimized were the current density, electrode spacing, electrode arrangements, and Liquid Motion Driving Mode (LM). Based on the regression model and the analysis of variance (ANOVA) at 0.01%, the results showed that an increase in current density and LM-MS increased the removal efficiency while the reverse was the case for electrode spacing. The model predicted the optimal lead removal efficiency of 99.962% with an electrode spacing of 0.38 cm alongside others. Applying the predicted parameters, the lead removal efficiency of 100% was actualized. The electrode and energy consumptions were 0.192kg/m3 and 2.56 kWh/m3 respectively. Meanwhile, the adsorption kinetic studies indicated that the overall lead adsorption system belongs to the pseudo-second-order kinetic model. The adsorption dynamics were also random, spontaneous, and endothermic. The higher temperature of the process enhances adsorption capacity. Furthermore, the adsorption isotherm fitted the Freundlish model more than the Langmuir model; describing the adsorption on a heterogeneous surface and showed good adsorption efficiency by the Fe electrodes. Adsorption of Pb2+ onto the Fe electrodes was a complex reaction, involving more than one mechanism. The overall results proved that EC is an efficient technique for lead removal from synthetic mining pond water. The findings of this study would have application in the scale-up of EC reactor and in the design of water treatment plants for feed-water sources that contain lead using the electrocoagulation method.

Keywords : ex-mining water, electrocoagulation, lead, adsorption kinetics
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