Statistical optimization of titanium recovery from drinking water treatment residue using response surface methodology

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ABSTRACT

Water treatment plants generate vast amounts of sludge and its disposal is one of the most expensive and environmentally problematic challenges worldwide. As sludge from water treatment plants contains a considerable amount of titanium, both can create serious environmental concerns. In this study, the potential to recover titanium from drinking water treatment residue was explored through acid leaching technique. Statistical design for the optimization of titanium recovery was proposed using response surface methodology (RSM) based on a five-level central composite design (CCD). Three independent variables were investigated, namely the acid concentration (3 M–7 M), temperature (40 °C – 80 °C) and solid/liquid ratio (0.005–0.02 g/mL). According to the analysis of variance (ANOVA), the p-value (<0.0001) indicated the designed model was highly significant. Optimization using RSM gave the best fit between validated and predicted data as elucidated by the coefficient of determination with R^2 values of 0.9965. However, acid concentration and solid/liquid ratio showed an initial increase in titanium recovery followed by recovery reduction with increasing concentration and ratio. Quadratic RSM predicted the maximum recovery of titanium to be 67.73% at optimal conditions of 5.5 M acid concentration, at a temperature of 62 °C with a solid/liquid ratio of 0.01 g/mL. The verification experiments gave an average of 66.23% recovery of titanium, thus indicating that the successfully developed model to predict the response. This process development has significant importance to reduce the cost of waste disposal, environmental protection, and recovery of economically valuable products.

KEYWORDS

Acid leaching; Titanium recovery; Response-surface methods; Water-treatment sludge; Waste recycling

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