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Environmental Performance of Different Lab Scale Chromium Removal Processes

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Abstract : Chromium-contaminated wastewater from electroplating industrial activity has been a long-standing environmental issue, as it can degrade surface water quality and is harmful to soil ecosystems. The traditional method of treating chromium-contaminated wastewater has been to use chemical coagulation processes. However, this method consumes large amounts of chemicals such as sulfuric acid, sodium hydroxide, and sodium bicarbonate in order to remove chromium. However, a series of new methods for treating chromium-containing wastewater have been developed. This study aimed to compare the environmental impact of four different lab scale chromium removal processes: 1.) chemical coagulation process (the most common and traditional method), in which sodium metabisulfite was used as reductant, 2.) electrochemical process using two steel sheets as electrodes, 3.) reduction by iron-copper bimetallic powder, and 4.) photocatalysis process by TiO2. Each process was run in the lab, and was able to achieve 100% removal of chromium in solution. Then a Life Cycle Assessment (LCA) study was conducted based on the experimental data obtained from four different case studies to identify the environmentally preferable alternative to treat chromium wastewater. The model used for calculating the environmental impact was TRACi, and the system scope includes the production phase and use phase of chemicals and electricity consumed by the chromium removal processes, as well as the final disposal of chromium containing sludge. The functional unit chosen in this study was the removal of 1 mg of chromium. Solution volume of each case study was adjusted to 1 L in advance and the chemicals and energy consumed were proportionally adjusted. The emissions and resources consumed were identified and characterized into 15 categories of midpoint impacts. The impact assessment results show that the human ecotoxicity category accounts for 55 % of environmental impact in Case 1, which can be attributed to the sulfuric acid used for pH adjustment. In Case 2, production of steel sheet electrodes is an energy-intensive process, thus contributed to 20 % of environmental impact. In Case 3, sodium bicarbonate is used as an anti-corrosion additive, which results mainly in 1.02E-05 Comparative Toxicity Unit (CTU) in the human toxicity category and 0.54E-05 (CTU) in acidification of air. In Case 4, electricity consumption for power supply of UV lamp gives 5.25E-05 (CTU) in human toxicity category, 1.15E-05 (kg Neq) in eutrophication. In conclusion, Case 3 and Case 4 have higher environmental impacts than Case 1 and Case 2, which can be attributed mostly to higher energy and chemical consumption, leading to high impacts in the global warming and ecotoxicity categories.

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