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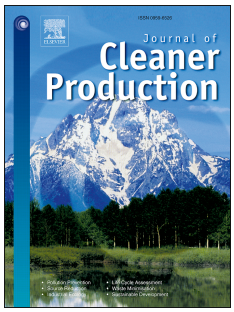

Life cycle assessment comparison of industrial effluent management strategies

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Life cycle assessment comparison of industrial effluent management strategies

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Abstract

A process model was analysed with life cycle assessment (LCA) to evaluate the environmental tradeoffs of fourteen process alternatives treating a pulp and paper effluent with high levels of chemical oxygen demand (COD) and adsorbable organic halides (AOX). The process alternatives were constructed from six unit processes: dissolved air flotation, clarification, activated sludge, upflow anaerobic sludge blanket reactor, ultrafiltration and reverse osmosis (RO) treatment. The tradeoffs between different environmental impact categories were investigated, with a focus on eutrophication, freshwater aquatic ecotoxicity (FWAE), greenhouse gas (GHG) emissions and water extraction. By explicitly considering the water recovery function of the alternative configurations, the water recovery and contaminant removal effectiveness were compared against GHG emissions.

While the most intense option was able to reduce AOX by 99.6% and COD by 99.9%, the FWAE and eutrophication categories had a reduction of only 98.6% and 94.2%, respectively. The GHG emissions were heavily influenced by sludge landfilling contributing between 39% and 71% of overall emissions, with electricity production becoming significant as treatment intensity increased. The alternatives considered were able to produce a recycled water stream composed of 3% to 100% of treated effluent. Configurations using RO produced effluent with sufficient quality to be used in recycled water applications without dilution. Configurations with ultrafiltration as the highest level of treatment could produce a recycled water stream composed of 35% to 81% treated effluent. Contaminant discharge impacts, water recovery and GHG emissions did not have a single optimal configuration. The study demonstrate the ability of this model to identify marginal tradeoffs between environmental impacts, measure quality of recycled water produced by different treatment technologies, which provides a measure of system effectiveness.

Keywords: life cycle assessment (LCA), wastewater treatment, energy, greenhouse gas (GHG) emissions, water reuse, water quality, process water

1 Introduction

For large scale industrial water users and effluent generators such as the pulp and paper industry, water recycling has the potential to reduce multiple environmental impacts associated with effluent management and generate new revenue streams. Traditional treatment of effluent streams focuses on removing contaminants to prevent environmentally damaging discharges to water bodies, often at the expense of an increase in energy consumption, chemical usage and infrastructure inputs. Advanced effluent management incorporates resource recovery strategies, in particular water