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ScienceDirect
Desalination 246 (2009) 45–54
DESALINATION
www.elsevier.com/locate/desal

Eichhornia crassipes used as tertiary color removal treatment for Kraft mill effluent

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Received 14 October 2007; revised 28 December 2007; accepted 04 March 2008

Abstract

Chile annually produces 2 million tons of kraft mill pulp using pine and eucalyptus as raw materials. In spite of the primary and secondary treatment processes installed in almost all of the industries, the discharged effluents still contain color, affecting light transmission in aquatic systems. At present, 75 tons of color is produced daily by industrial processes that require 57,000 m^3/d of fresh water for processing.

This chapter evaluates a tertiary treatment with *Eichhornia crassipes* that is used to remove color and organic compounds from kraft mill effluent.

E. crassipes removed 46–75% of organic matter and 11–17% of total phenolic compounds. Under experimental conditions, *E. crassipes* was able to remove around 8.5% and 23.6% of color when the assays were done with 50% and 10% kraft mill effluent, respectively.

Keywords: *Eichhornia crassipes*; Color; Aromatic compounds; Biodegradation; Kraft mill effluent

1. Introduction

Chile annually produces 2 million tons of kraft mill pulp using pine and eucalyptus as raw materials. In the last few years, kraft mills have substantially updated pulping and bleaching technologies, transforming the effluent's biodegradation and toxicity, although these effluents still require primary and secondary treatments. Organic substrate content in the kraft mill effluents may be reduced by secondary treatment [1], although it is well known that color and specific compounds remain even after biological treatment due to diverse aromatic compounds, ranging from simple monomers to high molecular weight (MW) polyphenolic polymers, often found in the aerobic effluent [2–4]. At present, 75 tons of color is produced daily by an industry that requires 57,000 m^3/d fresh water for the process. The high MW fraction of the total organic chlorides

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Presented at Multi Functions of Wetland Systems, International Conference of Multiple Roles of Wetlands, June 26–29, 2007, Legnario (Padova) Italy

doi:10.1016/j.desal.2008.03.042

(MW > 1000 Da) is only slightly affected by an aerobic treatment, and chemical oxygen demand (COD) removal will generally not exceed 45% with these systems [5,6]. Still, Diez *et al.* [7] indicate that high MW aromatic components, such as lignin and tannins, are simply not biodegradable in aerobic environments. Similar results were shown by Rintala and Lepistö [8], who worked with an anaerobic–aerobic sequence to treat thermomechanical pulping whitewater. Recent studies suggest that the color increase in kraft mill biological treatment systems may be caused by anaerobic bacteria using high MW material from bleaching effluents as an electron acceptor for growth, resulting in material reduction, which in turn leads to nonreversible internal changes, such as intramolecular polymerization or the formation of chromophoric functional groups [9].

Since the color discharged could affect light transmission in aquatic systems, color removal by an alternative tertiary treatment or physicochemical treatment must be explored [1].

Eichhornia crassipes, a dominant floating macrophyte present in natural lakes in Chile, has a high capacity to incorporate nitrogen from both ammonium and nitrate sources [10,11] as well as a large submerged root system that supplies oxygen to the rhizosphere. Previous studies show that *E. crassipes* is able to remove nitrogen in a range between 50.1 and 163.0 mg N/g dry weight [10,11]. Additional studies demonstrate that the biomass yield increases with an increase of phosphorus supply up to 1.06 mg P/l; under that condition, phosphorus content from 3.8 to 4.3 mg P/g was measured in the plant tissue [12,13].

On the one hand, specific studies with aromatic compounds show that *E. crassipes* could remove these compounds with adsorption mechanisms [14] and/or biodegradation [15]. Thus, basic dyes, such as methylene blue and Victoria blue, are removed when *E. crassipes* is used as sorbent. Maximum sorption capacities of water hyacinth roots for methylene blue and Victoria blue were 128.9 and 145.4 mg/g, respectively [14]. On the other hand, 2.75 g dry matter of *E. crassipes* demonstrated the ability to absorb 100 mg of phenol in 72 h [15]. Moreover, Nor [16] shows that this aquatic plant is able to completely remove 200 mg/l of phenols in the presence of trace metals (Cu, Zn) after an hydraulic retention time of 6 h. Still, no report studying color and aromatic compound behavior in the presence of aquatic plants was found.

The objective of the present study is to evaluate color removal and aromatic compound behavior in kraft mill effluents during tertiary treatment by *E. crassipes*.

To corroborate aromatic behavior and color removal, the behavior of Poly R-478 as a model compound was studied in parallel.

2. Materials and methods

2.1. Effluent

Effluent was obtained from a kraft mill that uses elementary chlorine free pulp bleaching process. Effluent was collected after primary treatment, which consisted in a settling tank to reduce fiber and suspended solid content.

2.2. Plants

Collection *E. crassipes* was collected at the beginning of spring from the Tres Pascualas lagoon, VIII Region, Concepción, Chile (36° 49′S; 73° 03′W). New plants (with new green lips from the spring season) were selected; the longest and abundant leaves (four or five leaves for each plant) were used as a classification index. The plant's root length and size were also considered. Plants were collected directly from the lagoon and transported in an appropriate container with water from the lagoon.

Assay inoculation Each pond was inoculated with five plants. The biomass of each of the five plants from each pond was measured at the inoculation, and then at 3 and 6 months