Chemical Engineering Journal 210 (2012) 263–270

Contents lists available at SciVerse ScienceDirect

Chemical Engineering Journal

journal homepage: www.elsevier.com/locate/cej

A simultaneous removal of beryllium and ammonium–nitrogen from smelting wastewater in bench- and pilot-scale biological aerated filter

Fang Sun, Wei-Ling Sun *

College of Environmental Sciences and Engineering, Peking University, The Key Laboratory of Water and Sediment Sciences, Ministry of Education, Beijing 100871, China

HIGHLIGHTS

- Simultaneous removal of beryllium and NH_4^+—N by biological aerated filter reactor was studied.
- High accumulation rates of beryllium inside the microbial cells was observed.
- The main removal mechanisms of beryllium were precipitation, complexion and bioaccumulation.
- N-oxidizing and metal-resistant bacteria were found in pilot-scale reactors.

ARTICLE INFO

Article history:
Received 27 April 2012
Received in revised form 30 August 2012
Accepted 3 September 2012
Available online 9 September 2012

Keywords:
Beryllium
Ammonia–nitrogen
Removal
Biological aerated filter

ABSTRACT

Heavy metal and NH_4^+—N co-contaminated wastewater are frequently found, and the presence of NH_4^+—N makes it extremely difficult to treat. In the present study, bench-scale and pilot-scale experiments were conducted to investigate the simultaneous removal of beryllium and NH_4^+—N from smelting wastewater by biological aerated filter (BAF) reactors. The results of the five-stage BAF reactors showed that the system could endure shock loadings. The average removal efficiency for beryllium and NH_4^+—N was 92.6% and 95.0%, respectively. Sequence extraction indicates that the primary removal mechanism in the first two reactors was precipitation, whereas the organic-bound fraction was predominant in the last three reactors due to the high accumulation rates of beryllium inside the microbial cells. Polymerase chain reaction and denaturing gradient gel electrophoresis (PCR–DGGE) and sequence analysis of 16S rDNA gene fragments showed that N-oxidizing bacteria (*Nitrosomonas* sp. and Beta proteobacterium CH24i) were primarily detected in the first two BAF reactors, in accordance with their high NH_4^+—N removal efficiencies, and metal-resistant bacteria (*Actinobacteria* sp.) were found in all BAF reactors.

1. Introduction

Heavy metal pollution has become one of the most serious environmental problems. Many industries produce metal-containing wastewater, including mining and smelting, surface finishing, electroplating, and photography [1]. Heavy metals discharged into the environment cannot be degraded, and they accumulate in the food chain, posing a serious health threat to humans and other species [2]. The composition of industrial wastewater is complex and always contains many different types of pollutants, which makes it extremely difficult to treat. For example, the wastewater from mineral extraction industries contains heavy metals and other harmful elements like NH_4^+—N and salts [3]; the wastewater from ceramic capacitor industries contains high concentrations of $Ni(NH_3)_4^{2+}$ complex ions [4]; copper and NH_4^+—N are frequently found in the effluents of tannery, explosives, and timber industries [5].

In previous studies on heavy metal and NH_4^+—N co-contaminated wastewater, the primary focus was on the removal of either heavy metals [6–8] or NH_4^+—N [9]. Few studies combined the metal removal process with the air tripping process to remove both contaminants simultaneously [4,10]. Along with small amounts of other heavy metals (Cu, Pb, Cd), the wastewater from a beryllium smelting plant also contain NH_4^+—N co-contamination, as NH_4^+—N is added to form $(NH_4)_2BeF_4$ crystal during the smelting process [11]. Be and its compounds are of high toxicity. Exposure to Be can cause acute chemical pneumonitis, chronic beryllium disease, and even cancer [12]. In previous studies, precipitation, ion-exchange, activated carbon and biomaterial sorption were introduced to remove metals from beryllium smelting wastewater [12–14]. However, no study was conducted to remove beryllium and NH_4^+—N simultaneously.

The biological aerated filter (BAF) reactor is regarded as an effective biological wastewater treatment method [15,16]. It can remove pollutants by carrier filtration and biodegradation [16]. Due to its advantages, which include high biomass retention, tolerance to toxicity, excellent removal efficiency, and slurry separation,

* Corresponding author. Tel./fax: +86 1062767014.
E-mail address: wlsun@pku.edu.cn (W.-L. Sun).

1385-8947/$ - see front matter © 2012 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.cej.2012.09.002