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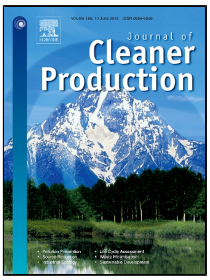

Copper recycle from sulfide tailings using combined leaching of ammonia solution and alkaline bacteria

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Copper recycle from sulfide tailings using combined leaching of ammonia solution and alkaline bacteria

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Abstract: The migration of heavy metals and loss of valuable resources have become indispensable limitations to the developments of metal mines because of failing to remediate tailings ponds. Furthermore, serious environmental pollution from mine drainage water, soil during metal recovery from tailings by conventional acid leaching processes cannot be ignored. Thus, in this study, to recover valuable metals and reduce pollution, a cleaner metal extraction method from copper sulfide tailings using a combined leaching method employing ammonia solution and a novel strain of alkaline bacteria under alkaline condition was explored. The phylogenetic tree of a novel strain of alkaline bacteria isolated from tailings ponds at the Yangla Copper Mine in China was constructed from 16s rDNA sequence, and its optimal cultivation conditions and leaching characteristics were determined. A comparison leaching with alkaline bacteria, ammonia or a combination of the two clearly indicated that copper recovery was remarkably better with combination that Cu extraction rate increased from 4.42 % (48 days, ammonia leaching) or approximately 20 % (30 days, alkaline bacterial leaching) to 29.57 % (30 days, combined leaching). The leaching mechanisms were discussed briefly. A synergistic effect between the alkaline bacteria and the ammonia solution was confirmed, especially at a lower ammonia concentration (30 g/L to 60 g/L). In addition, high ammonia concentration (> 60 g/L) inhibited bacterial activity and even killed the bacteria. Although the mechanism of combined leaching still requires intensive study, the results of our exploratory experiments could significantly contribute to a green recovery method from tailings.

Keywords: sulfide tailings; alkaline bacteria; combined leaching; copper bioleaching; ammonia leaching

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Highlights:

- Combined leaching method of ammonia solution and alkaline bacteria during copper tailings is explored
- A novel strain of alkaline bacteria isolated from copper sulfide tailings is presented.
- Comparison of ammonia leaching, bioleaching and combined leaching is researched.
- Synergistic effect of ammonia solution and alkaline bacteria during bioleaching of copper sulfide tailings is discussed.

1. Introduction

Mining engineering is an essential cornerstone and an impetus to promote progress and development of human beings (Brierley J., and Brierley C., 2001). However, owing to the migration of heavy metals, such as lead, gold and copper, and landslide hazards, potential environmental pollution of the surrounding soil and ground water (Amari et al., 2014; Beylot and Villeneuve, 2017; Kefeni et al., 2017) has become an unavoidable recurring problem caused by mine tailings, of which a massive after mineral processing (Nejeschlebová et al., 2015). Even though some alternative methods such as backfill technology using tailings were previously proposed for better environmental remediation (Sun et al., 2018), and higher social and economic outcomes (Edraki et al., 2014), the recovery of critical metals via bioresource technology (Petersen, 2016; Johnson, 2014; Luo et al., 2017) from mine tailings has not received enough attentions (Gomes et al., 2016; Yin et al., 2018).

Recently, except for the generation of mobility from tailings in the leachate (Hesketh et al., 2010; Hansen et al., 2008), more researchers have noticed and researched metal extraction and leaching mechanisms from tailings. For instance, the possibile evaluation of copper bioleaching from flotation tailings on a benchscale, commissioning and industrial tests (Kondrat'eva et al., 2012; Yin et al., 2017), electro-dialytic remediation of copper mine tailings in 2005 (Hansen et al., 2005), acid leaching of copper and zinc from flotation tailings using a H_2SO_4 solution and acid bacteria (Muravyov et al., 2012), potential effect of layered heap construction for the bioleaching of copper flotation tailings using mixed cultures (Hao et al., 2016), and the recycling of valuable substances by producing chemically bonded ceramics from tailings (Kinnunen et al., 2018) were researched. Key factors such as temperature and pH during leaching of heavy metals in the Dexing Copper Mine, China (Guo et al., 2013; Wu et al., 2009a), have also been researched, as have metal mobilization and accumulation under alkaline conditions using ash-covered tailings (Lu et al., 2014). In addition, to deal with environmentally disposals, a leaching and fractional precipitation method has been drawn into metal extraction from low-grade copper sulfide tailings (Chen et al., 2014), and bioleaching and sulfide precipitation has been used for the removal of metals from Lead-Zinc tailings (Ye et al., 2017). Studies of the combined bioleaching methods in multiple metals such as copper, nickel and cobalt from low-grade sulfidic tailings (Ahmadi et al., 2015) has also been conducted. Recently, accompanied by the development of genetic technology, metagenomic explorations of microbial communities and diversity in copper mine tailings have been carried out (Gupta et al., 2017; Korehi et al., 2014). All in all, although some novel approaches relevant to alkaline leaching such as two-stage mineral leaching and metal recovery protocol from tailings (Falagán et al., 2017), as well as the alkaline bioleaching of municipal solid wastes by autochthonous extremophiles (Remanathan and Ting, 2017) have been proposed, existing studies of copper extraction from solid wastes such as copper sulfide tailings, which are relevant to an alkaline leaching environment with bacteria, are remarkably lacking. In detail, these researches mainly focus on isolation of bacterium strain (Hu et al., 2016), the effects of key factors such as solid concentration (Liu, et al., 2007) on the removals process of heavy metal from mine tailings, flotation process of tailings via bioleaching, alkaline leaching mechanism of chalcopyrite (Eksteen et al., 2017), magnesium (Xu et al., 2018) and other