

# Strengthening of bioleaching of Cu and As by Static Magnetic Field with *Acidithiobacillus ferrooxidans* in tailings

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**Abstract.** Bioleaching was used in this paper to leach heavy metals from tailings; Static magnetic field was used to strengthen the leaching rate of heavy metal (such as As and Cu), under the conditions of magnetic induction intensity separately were 1 m T, 2 m T, 5 m T, 8 m T and 11 m T, The results showed that under the conditions of inoculum 10%, pulp density 5%, pH 2.0, leaching temperature 30 °C, different magnetic induction intensity, the leaching rate of Cu and As were increased, the best magnetic induction intensity in bioleaching of Cu and As were all 11 m T.

## 1. Introduction

Bioleaching is one of various kinds' methods which reclaim valuable metals or remove harmful components; It has some characteristics such as process simple, low energy consumption, environmental friendly and wide range of processing objects. However, the leaching rates of some metals was very low, many researchers began to research various kinds methods to strengthen bioleaching. Some researchers made use of ultraviolet rays, microwave and ultrasonic wave acting on bioleaching bacteria, made the bacteria mutagenesis and leached copper tailings by mutagenesis *Acidithiobacillus ferrooxidans*, results showed that oxidation activity of some mutagenesis bacteria was improved, leaching rate of metals was increased[1]. Optimum pH of some mutagenesis bacteria was decreased[2], acid resistance of some mutagenesis bacteria was enhanced[3], or other characteristics of some mutagenesis bacteria was changed[4]. Other researchers made use of chemical reagent, such as hydroxylamine hydrochloride[5], nitrous acid and Nitrosoguanidine. To act on bioleaching bacteria, this results showed that oxidation activity of some mutagenesis bacteria was improved by 37.4% and some mutagenesis bacteria was improved four times than before, except those methods, Utilization of magnetic field and electric field were another methods to improve the leaching rates of metals. Effecting on bioleaching bacterial growth and oxidative activity by magnetic field and electric field were researched in Bulgaria, Drzava and former Soviet Union[6]. They found that magnetic field and electric field would be a good method to strengthen leaching. Tshilombo studied effecting on bioleaching bacteria by electric field[7]. Wang Mo hui studied effecting on oxidation activity of bioleaching bacteria and the leaching rates of copper mine by magnetic field[8].

In this paper, we will strengthen leaching of copper tailing by Static Magnetic Field in Homemade biological reactor to study the variation of leaching rate of harmful components in copper tailing.

## 2. Materials and methods

### 2.1 Sample preparation

Copper tailing samples were collected from Yunnan, China. The particle size of samples was  $\leq 74 \mu\text{m}$ . The elemental compositions of samples were determined by ICP-OES. The detailed data of the elemental composition of samples were showed in table 1.

## 2.2 Bacterial and Culture medium

The *At.f* from abandoned pyrite mine drainage were prepared for bioleaching tests. The iron-free 9K medium is used to cultivate *Acidithiobacillus ferrooxidans* in this test. It contained: 3.00 g/L  $(NH_4)_2SO_4$  , 0.10 g/L  $KCl$  , 0.5 g/L  $K_2HPO_4$  , 0.5 g/L  $MgSO_4 \cdot 7H_2O$  , 0.01 g/L  $Ca(NO_3)_2$  ,  $FeSO_4 \cdot 7H_2O$  44.78 g/L .

## 3. Experimental device and method

The device in the test was DC (Direct Current) magnetics bioleaching system, that is a Helmholtz coils, which is a cylindrical device, it was twisted with copper wire outside. The magnetic field intensity of the system was calculated by equation (1),

$$B = 0.691 \frac{\mu_0 NI}{R} \quad (1)$$

In equation (1), the was space permeability,  $\mu_0 = 4\pi \times 10^{-7} T \cdot m / A$  ; The N presents the turns of coils(1400); I was direct current(0-0.36 A); the R was coils radius (4 cm).

Table 1 The content of some elements in Cu tailings

Element	Content (mg/g)	Element	Content (mg/g)
Cu	3.49065	As	1.2221136
Fe	141.931	Cd	0.06403
S	66.6592	P	0.59729
Zn	1.3706	Pb	0.33251

The bioleaching lasted 27 days. The pH and ORP were determined in the bioreactor using pH/ORP meter (ORP-421). As and Cu concentrations was measured by atomic fluorescence spectrometer (SK-2002B). Total iron and ferrous concentration were analyzed by the 10-phenanthroline method. The same leaching conditions were temperature 30°C, inoculum 10%, pulp density 5%, p H 2.0. The magnetic induction intensity was different, that separately were 0 m T, 1 m T, 2 m T, 5 m T, 8 m T and 11 m T.

## 4. Results and Discussions

Fig.1 and Fig.2 were the trend of pH and ORP during bioleaching. The leaching rates of Cu and As were showed in Fig. 3 and Fig. 4. The morphological analysis of Cu pre and post leaching was showed in Fig. 5.

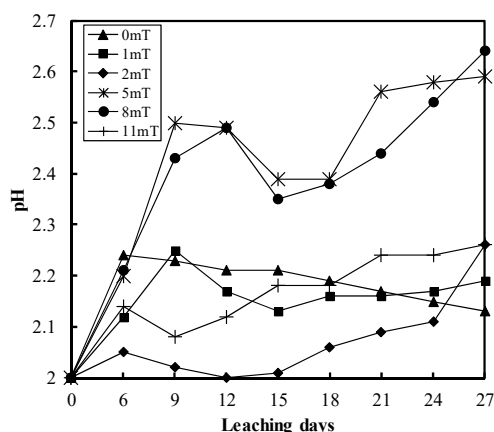


Fig.1 The trend of pH during bioleaching

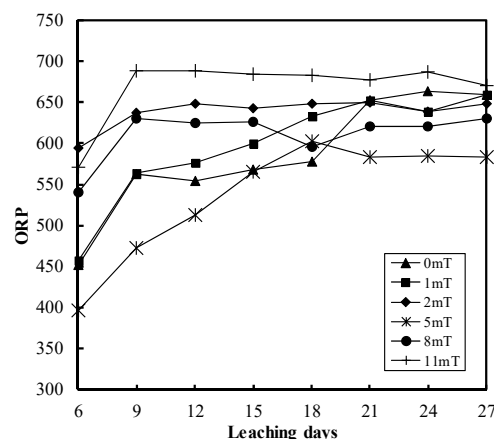


Fig.2 The trend of ORP during bioleaching

Fig. 1 showed the trend of pH. which was increased at the early leaching time, and then decreased later without magnetic field. However, the trend of pH were differently under the conditions of magnetic induction intensity separately were 1 m T、 2 m T、 5 m T、 8 m T and 11 m T. Because the vary of pH were influenced by magnetic field. Literature materials showed pH of water would arise under the conditions of magnetic field.

Fig. 2 showed that the trend of ORP. The trend of ORP was always gone up, and achieved between 550 mV to 700 mV at last. ORP was up to  $\text{Fe}^{3+}/\text{Fe}^{2+}$ , the higher the ORP was, the better oxidation activity of *At.f* was. The influence of magnetic field was obvious, ORP was highest under the conditions of magnetic induction intensity were 11 m T, the other ORP under the conditions of 1 m T, 2 m T, 5 m T ,8 m T were higher than without magnetic field some time, while lower than without magnetic field the other time.

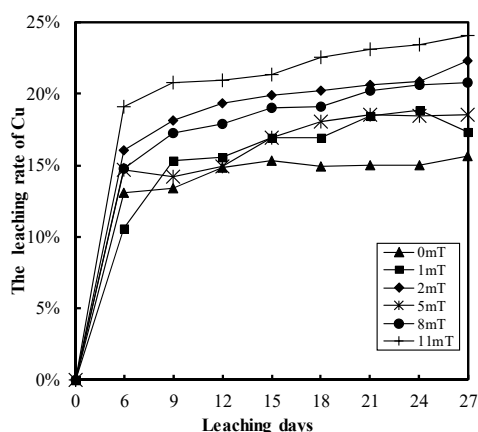


Fig.3 The leaching rate of Cu during bioleaching

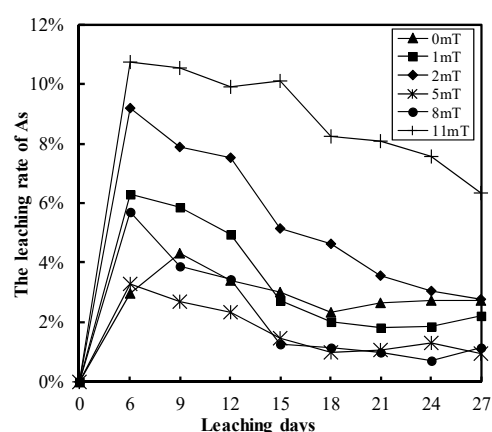


Fig.4 The leaching rate of As during bioleaching

Fig. 3 showed that the trend of Cu leaching rate. The leaching rate of Cu were increasing gradually along with the leaching time, the leaching rate of Cu of groups with electromagnetic field were higher than the group without electromagnetic field, that suggested leaching rate of Cu was impacted by magnetic induction. The highest leaching rate of Cu reached 24.06% under the conditions of 11 m T, which improved 8.34% from 15.6%. Thus it can be seen Electromagnetic field could strengthen bioleaching and improve the rate of Cu.

Fig. 4 showed that the trend of As leaching rate, the leaching rate of As were firstly increase then decrease along with the leaching time. The reasons of change trend different with other elements was that there were  $\text{FeAsO}_4$  precipitation when a large number of  $\text{Fe}^{3+}$  and  $\text{As}^{5+}$  were in solution, The number of days which the leaching rate increasing were 6 with electromagnetic field, but 9 days without electromagnetic field. The different of days was because of the influence of electromagnetic field. In a word, the leaching rate of As was increase by electromagnetic field, the best magnetic induction for As was 11 m T, the rate was 10.74%.

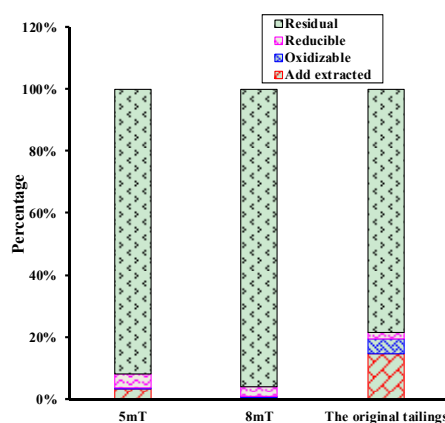


Fig.5 The content for Cu forms pre and post bioleaching

Fig.5 showed that the percentage content for Cu forms were changed after leaching with magnetic induction, the Acid extracted fraction of Cu decrease a lot after leaching, which transform Residual

fraction. And it was more stable to compare Extractable fraction(Acid extracted fraction, Oxidizable fraction, Reducible fraction), The higher the percent of Extractable fraction(Based on BCR sequential extraction, The forms of heavy metals are composed of oxidizable fraction, reducible fraction, acid extracted fraction and residual fraction[9]), the easier producing secondary pollution, the bigger biological effectiveness[10,11].

## 5. Discussion

Under the conditions of magnetic induction intensity separately were 1 m T、 2 m T、 5 m T、 8 m T and 11 m T, bioleaching of copper tailing was researched with self-made bioreactor using *At.f* in this paper. Form the test of leaching, it indicated that Static Magnetic Field influenced on the leaching rate of heavy metals in tailings. The results showed that under the conditions of inoculum 10%, pulp density 5%, pH 2.0, leaching temperature 30℃, different magnetic induction intensity, the leaching rate of Cu and As separately were increased from 15.6% and 4.32% to 24.06% and 10.74%, the best magnetic induction intensity in bioleaching of Cu and As were all 11 m T. Besides, According to the morphological analysis, the forms of Cu was changed after leaching, which became more stable.

In short, Static Magnetic Field could strengthen leaching of heavy metals in Cu tailings.

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