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The Effect of Ag^+ ION Existence in the Cyanidation Process of Tailing of Cijiwa Gold Ore Process on Gold Recovery

Esthi Kusdarini [1], **Agus Budianto** [2], **Erwin Rangga Fitriawan**[3]

[1,3]Mining Engineering Department, Faculty of Mineral & Ocean Technology, Adhi Tama Surabaya Institute of Technology, Surabaya, 60117, Indonesia.

[1]Student of Environmental Science Doctoral Program, Brawijaya University, Malang, 65145, Indonesia.

[2]Chemical Engineering Department, Faculty of Industrial Technology, Adhi Tama Surabaya Institute of Technology, Surabaya, Indonesia.

Abstract

Tailings still contain gold that allows to be extracted again. Some tailings contain silver which can affect the effectiveness of leaching. The purpose of this research is to examine the effect of Ag^+ ion existence on cyanidation process of gold ore processing to Au recovery. The test is done by adding silver nitrate ($AgNO_3$) to the leaching process. The experiment was conducted five times. The feed capacity was 200 kg with the addition of $AgNO_3$ of 0 g, 1 g, 2 g, 3 g, and 4 g. The leachate solution was circulated through the activated carbon for 24 hours. Au content in activated carbon was analyzed using atomic absorption spectrophotometry (AAS) method. The results showed that Au recovery in addition of $AgNO_3$ 0 g, 1 g, 2 g, 3 g, and 4 g respectively was 9.62%; 8.99%; 8.91%; 7.30%; and 6.41%. The Ag^+ ion contained in the tailings decreases the Au recovery because the Ag^+ ions can be bound by cyanide ions which interfere with the binding of Au^+ ions by the cyanide ion.

Keywords: silver ion, recovery Au, cyanidation, tailing, spectrophotometry method

INTRODUCTION

Most of the people of Kertajaya village, Simpenan subdistrict, Sukabumi regency, West Java have profession as miner and processor of gold ore. One of the ways that people use to process gold ore is by cyanidation process. Each treatment will produce solid and liquid waste. The more gold ore being processed, the greater the solid waste or tailings produced. Research shows that the Au recovery of Cijiwa gold ore reaches 13 - 36% so there is still quite a lot of Au contained in tailings[1]. Au content in tailings can reach 4.41 ppm[2]. Au content in tailings of this size is still economical and interesting to be reprocessed. Tailings processing has two advantages: reducing environmental pollution and increasing employer profits.

In the cyanidation process, people prefer the heap leaching method rather than vat leaching and agitated leaching. This selection is based on economic considerations and ease of operation[3]. In general, Leaching uses a cyanide solution[1], however, studies show that microorganisms may replace the cyanide solution[4]. Tailings processing requires better handling of ore processing. This is because the Au content in the tailings is lower than in the ore. In addition to the lower Au content, tailings also still have the potential to contain dominant impurities such as Ag and S[1].

The improvement of Au recovery has been sought by previous researchers. These efforts include seeking optimal operating conditions, increasing the dissolved oxygen in the concentrate, and reducing the amount of impurity miner[5]. One way to increase dissolved oxygen is by adding hydrogen peroxide (H_2O_2)[6]. Mineral impurities should be minimized before the tailings are dissolved into the cyanide solution. This is due to the ability of the cyanide solution to bind the impurities which will interfere the binding of Au^+ and CN^- ions. Mineral impurities have potential to disturb the binding reaction of Au^+ ions by CN^- ions. The reduction of impurity minerals from gold ores has also been investigated. Methods to reduce impurity minerals are adjusted for the type of impurity minerals. The manganese (Mn) element is reduced by FeS and H_2SO_4[7]. While the element of arsenic is reduced by nanosorbent Fe_3O_4@SiO_2@TiO_2[8].

The dominant impurity miner contained in Cijiwa gold ore is sulphide minerals, such as pyrite (FeS_2), chalcopyrite ($CuFeS_2$), sphalerite (ZnS), arsenopyrite (FeAsS), covellite (CuS), and calcalk (Cu_2S)[1]. Previous research has shown that the addition of $AgNO_3$ to the concentrate is capable of binding the S^{2-} ion thereby reducing the thiosulfate ion and thiocyanate ion formed to prevent the disturbance of the oxygen supply[1]. Although the study showed that the addition of $AgNO_3$ was able to improve the Au recovery on ore processing, it has not known yet to have any effect when it was done to treat tailings which certainly contained different elements with ores.

MATERIALS AND METHODS

Tools and Materials

The materials used are tailings, technical NaCN (PT Insoclay Acidatama Indonesia), limestone (CaO), $AgNO_3$ p.a. (Merck), pH meter, water, and activated carbon from coconut shell (Kyodo Yushi), HCl p.a. 37% (Merck), and HNO_3 p.a. (Merck). While the tools used are scales, pumps, sprinklers, buckets, gauze, stirrer, paralon pipes, waterproof tarp from high density polyethylene material, and analytic balance.

The Research Procedure

The first step is weighing of 200 kg of tailings for 5 times. At each weighing, sampling and analyzing Au content in tailings was performed using the AAS method. The second step is to put 200 kg of tailings in the processing tub. The third step is the addition of silver nitrate ($AgNO_3$), 400 grams of sodium cyanide (NaCN), 50 grams of chalk (CaO), and 99 liters of water into the tailings. Cyanide needs range from 0.5 to 5 kg per ton of feed[3]. The processing tub is in the form of waterproof solid (high density polyethylene) to prevent air pollutant infiltration against the soil. To facilitate the circulation of the concentrate stream, a slope of 3º to 6º is formed on the bottom of the tub. The variables used in this study were $AgNO_3$ concentration of 0 gram, 1 gram, 2 gram, 3 gram, and 4 gram that added to 200 kg tailings. The addition of CaO to the tailings is given in solution form. CaO solution used for conditioning the pH of the concentrate around 11-12 for optimal Au recovery[9]. The addition of Ag^+ ion in $AgNO_3$ form aims to test the effect of Ag^+ ion on Au recovery. After the addition of $AgNO_3$, NaCN solution is sprayed through sprinkler. The rich solution (concentrate) is expected to contain many Au + ions bound by CN^- so that Au recovery can be optimal.

In the leaching process, dissolution of metal minerals will occur. The oxidation reaction of Au metal can be seen in (1)[10]. Furthermore, the oxidation reaction of impurities minerals can be seen in (2), (3) and (4)[3].

$$4\,Au + 8\,NaCN + O_2 + 2\,H_2O \longrightarrow 4\,NaAu(CN)_2 + 4\,NaOH \quad (1)$$

$$Cu_2S + 6NaCN \longrightarrow 2Na_2[Cu(CN)_3] + 2Na^+ + S^{2-} \quad (2)$$

$$ZnS + 4NaCN \longrightarrow Na_2[Zn(CN)_4] + 2Na^+ + S^{2-} \quad (3)$$

$$FeS + 6NaCN + 2O_2 \longrightarrow Na_4[Fe(CN)_6]^{4-} + Na_2[SO_4] \quad (4)$$

In equations (2) and (3) the S^{2-} ion is formed. This ion can react with oxygen to form thiosulfate ions as in (5). Additionally S^{2-} ions could react with CN^- ions and oxygen to form thiocyanate ions as in equation (6).

$$2\,S^{2-} + 2\,O_2 + H_2O \longrightarrow [S_2O_3]^{2-} + 2\,OH^- \quad (5)$$

$$S^{2-} + CN^- + 0{,}5\,O_2 + H_2O \longrightarrow CNS^- + 2\,OH^- \quad (6)$$

After leaching process that takes about 30 minutes, the concentrate is circulated and passed through the activated carbon in the column (CIC). The circulation process is carried out for 24 hours[9]. The flow of concentrate circulation is shown in Figure 1.

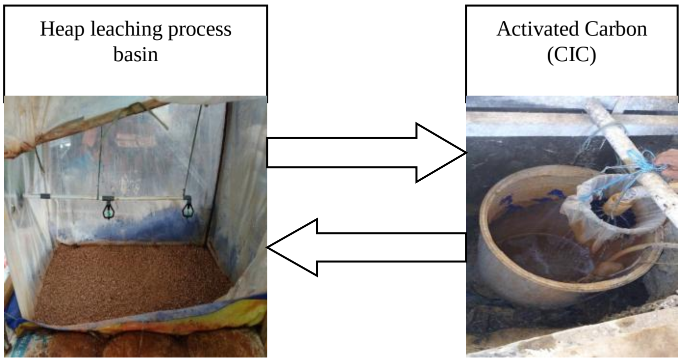

Figure 1. The flow of concentrate circulation

To determine the Au content in tailings (feed) and concentrate, AAS analysis was performed on the sample. AAS test was done at Geotek LIPI laboratory, Bandung, West Java, Indonesia. The next step was to burn the activated carbon to produce the bullion as presented in Figure 2. Bullion contains Au, Ag, and other metals.

Figure 2. Bullion result in gold extraction from tailings waste by heap leaching method and silver nitrate material assistance.

Au Recovery

Au mass conservation laws is applied to the cyanidation process. The incoming Au mass must be equal to the Au mass out plus the accumulated Au mass. Au recovery is obtained from equation (7)[3].

$$\text{Au Recovery} = \frac{\text{AuMass(consentrate)}}{\text{AuMass(tailing / feed)}} \times 100\% \quad (7)$$

RESULT AND DISCUSSION

This study studied the effect of Ag^+ ion existence on feed to Au recovery on re-processing of tailings using cyanidation process.

Au Concentration in Feed and Concentrate

Au content in tailings (feeds) is 3.63 ppm average. The feed mass per test is 200 kg so the Au mass is about 0.726 g contained in 200 kg of rock. While Au content in concentrates or rich solutions is presented in Table 1.

Table 1: Au concentration in concentrate

Test	Au Concentration (ppm)	
	Feed	Concentrate
1	3.63	0.71
2	3.45	0.62
3	3.28	0.60
4	4.06	0.64
5	4.08	0.55

To calculate the Au weight contained in the concentrate, the density of the concentrate is calculated as presented in Table 2.

Table 2: Concentrate density

Test	Concentrate Density (g/mL)
1	1.00
2	1.00
3	0.98
4	0.94
5	0.96

Based on Table 1 and Table 2, the Au mass contained in concentrates is presented in Table 3.

Table 3: Au mass in concentrate

Test	Au mass in concentrate (g)
1	0.0699
2	0.0620
3	0.0584
4	0.0593
5	0.0523

Au Recovery

Based on equations (2), Table 1, and Table 3, the Au recovery is obtained as presented in Table 4.

Table 4: Au recovery

Test	Addition of $AgNO_3$ (g)	Recovery (%)
1	0	9.62
2	1	8.99
3	2	8.91
4	3	7.30
5	4	6.41

The effect of $AgNO_3$ concentration into concentrate on Au recovery is presented in Figure 3.

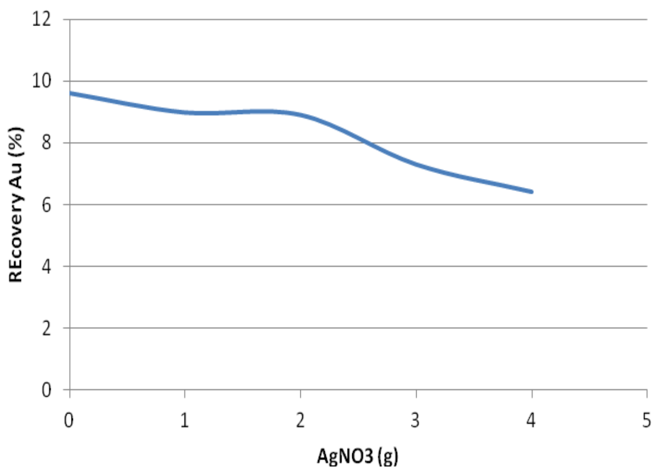

Figure 3. Effect of AgNO3 concentration on heap leaching process with cyanide solution to Au recovery from tailings waste in Kertajaya village

In Figure 3 we can see the effect of adding $AgNO_3$ to 200 kg of tailings (feed) to Au recovery. Figure 3 shows that the greater the addition of $AgNO_3$, the smaller the Au recovery. The largest Au Recovery of 9.62% was achieved under conditions without the addition of $AgNO_3$. This trend is in contrast when compared with the addition of $AgNO_3$ in the processing of gold ore which can improve the recovery of Au [1]. This is probably due to the tailings feed, the sulphide mineral content is not as much in the ore so that Ag^+ ions reacting with the S^{2-} ion forming less Ag_2S precipitate than in ore processing[11]. Furthermore, the excessive Ag^+ ion in the concentrate has a great opportunity to react with the CN-ion, thereby minimizing the chance of Au^+ ions to be bound to CN^- ions.

CONCLUSION

The presence of Ag^+ ions in the tailings disrupts the cyanidation process because it minimizes the chance of Au^+ ions to be bound to CN^- ions. The results showed that the addition of $AgNO_3$ of 1 to 4 g into 200 kg feed in the form of tailings has decreased the Au recovery from 9.62% to 6.41%. Recovery Au can be improved by performing physical pretreatment, such as a tool that uses the concept of gravitational concentration.

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