Journal of Metallurgical Engineering and Processing Technology, Vol. 4, No. 2
February, 2024
P-ISSN: 2723-6854, E-ISSN: 2798-1037, page 32-40
DOI: https://doi.org/10.31315/jmept

AAS and XRD Analysis of Gold Ore Bioflotation Results with Aloe Vera as an Environmentally Friendly Reagent

Sabrina Mantika[1], Farra Diva Prillasasti[1], Evan Nugrah Aurigha[1], Rike Amelia[1], M. Fajar Rickiadi[2], Tri Wahyuningsih[1]
[1]Universitas Pembangunan Nasional "Veteran" Yogyakarta
[2] PT Antam Tbk IUP OP Arinem
*Corresponding author : 116200019@student.upnyk.ac.id

Received 08/12/2023; Revised 19/01/2024; Published 28/02/2024

Abstract

Flotation is a mineral concentration method that involves floating the minerals so that they can be separated from the gangue by the addition of reagents. The reagents used are chemicals such as frother and collector, which can potentially contaminate the environment. This research explores the potential use of aloe vera as a separating reagent in environmentally friendly gold ore flotation. The feed used consists of 300 grams of gold ore, and the flotation time is set at 15 minutes. XRD analysis is employed to determine the types of minerals contained in the sample, revealing that the sample consists of 97.64% quartz; Enstatite, syn 1.21%; and Clinochlore-1A 1.16%. AAS analysis indicates an Au concentration in the feed of 3.94 ppm. The Au concentration in the concentrate with the addition of aloe vera extract is 10.57, and in the tailings, it is 0.92, higher than the concentration in the concentrate without the addition of aloe vera extract, which is 10.11, with 1.89 in the tailings. The %recovery from these concentrations with the addition of aloe vera extract is 84.06%, while without the addition of aloe vera extract, it is 63.78%. This study provides evidence that the use of aloe vera in the gold ore flotation process can be a sustainable and environmentally friendly alternative in the effort to improve the separation of valuable minerals from impurities.
Keywords: Bioflotation; Gold Ore; Aloe Vera Extract, Mineral Processing

Introduction

Flotation is one of the separation processes between valuable minerals and their gangue by exploiting the physicochemical properties of mineral particle surfaces. Mineral particles exhibit both hydrophilic and hydrophobic characteristics (Adji & Shima Parameswari, 2022). Minerals with hydrophobic properties will attach to air bubbles and rise to the surface, forming a froth. The generated froth is collected and dried to obtain the desired valuable minerals(Anjar Oktikawati et al., 2023).

The flotation process can be categorized into two types: Directional Flotation and Reverse Flotation. Directional Flotation is a process where valuable minerals are lifted to the surface, forming a froth that floats on the pulp's surface. On the other hand, Reverse Flotation is a flotation process where the floated mineral particles are impurities (gangue) (Fadel Sidiq, 2021)

Journal of Metallurgical Engineering and Processing Technology, Vol. 4, No. 2
February, 2024
P-ISSN: 2723-6854, E-ISSN: 2798-1037, page 32-40
DOI: https://doi.org/10.31315/jmept

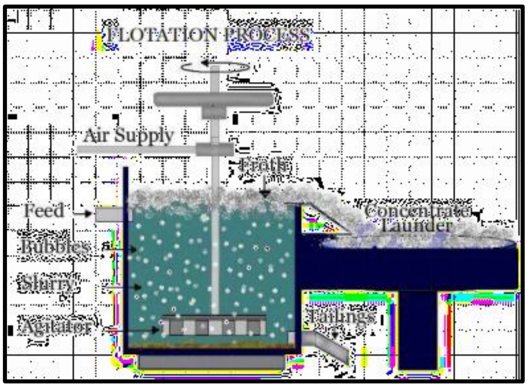

Figure 1. Flotation Process Scheme

Bioflotation is a process for separating valuable minerals from ores or other materials using hydrophobic microorganisms or chemicals produced by these microorganisme. In bioflotation, hydrophobic microorganisms or these chemicals adhere to the surface of valuable minerals, allowing them to rise to the water surface and be separated from other materials. This process is employed in the mining industry to separate valuable minerals such as copper, zinc, and gold from their ores. It involves the use of microbes such as bacteria, fungi, and algae naturally found in the ore mineral environment. These microbes induce a flotation effect on the desired minerals, facilitating their separation from undesired minerals. Bioflotation can be applied to process metal ores like copper, zinc, lead, nickel, molybdenum, and gold. This process can also be implemented for non-metallic ores like phosphate and limestone. However, the suitability of ore types for bioflotation depends on the chemical and physical properties of the ore, as well as the microorganisms or chemicals utilized in the process(Wahyuningsih Tri et al., 2017).

Gold is a chemical element with the symbol Au (from the Latin "aurum") and atomic number 79. Gold possesses a distinctive yellow color and is one of the rarest metals on Earth. It exhibits high chemical stability, corrosion resistance, and excellent thermal and electrical conductivity. Gold also has siderophile properties (weak affinity for oxygen and sulfur; high affinity for metals), tending to concentrate in residual hydrothermal fluids and subsequent metal or sulfide phases, rather than in silicates formed during the early stages of magma cooling. Gold is also found in areas undergoing metal extraction processes on the Earth's surface, such as in regions surrounded by rivers or water. The processes bringing gold to the Earth's surface can result in the formation of gold accumulations known as "placer deposits," typically composed of larger and more well-composed gold particles (Widi Astuti et al., 2018).

Gold-bearing minerals are typically associated with accompanying minerals (gangue minerals). These accompanying minerals commonly include quartz, carbonate, tourmaline, fluorspar, and a small quantity of non- metallic minerals(Abdul Latif, n.d.). Gold-bearing minerals also associate with oxidized sulfide deposits. Gold-bearing

Journal of Metallurgical Engineering and Processing Technology, Vol. 4, No. 2
February, 2024
P-ISSN: 2723-6854, E-ISSN: 2798-1037, page 32-40
DOI: https://doi.org/10.31315/jmept

minerals consist of native gold, electrum, gold tellurides, various alloys, and gold compounds containing sulfur, antimony, and selenium elements. Gold is often associated with many minerals that typically form rocks. Based on their ease of extraction, gold ores are classified into three types: free-milling, complex and refractory. Free-milling gold ores can be extracted by conventional cyanidation methods and are not too fine in size with extraction percentages of more than 90% (Adams, 2005).

Gold can form in very small sizes within solid solutions contained in sulfide mineral grains. Common sulfide minerals containing gold include arsenopyrite, pyrite, tetrahedrite, and chalcopyrite. This type of gold is commonly referred to as refractory ore. For refractory type gold, gold is generally inclusions in sulfide minerals that are stable and non-porous, making leaching difficult (Zhou, 2012). Gold is always found in metallic mineral rocks that contain sulfur, including high- sulfide rock formations. In pyrite-type rocks, the gold content is generally between 0.2 grams/ton and 7 grams/ton. Pyrrhotite-type rocks have gold contents ranging from 0.2 grams to 30 grams per ton of ore, and in arsenopyrite-type rocks, gold content can be found in much higher quantities. High-sulfide gold- bearing rocks are challenging to process using conventional methods due to the abundance of sulfur and base metals in the rocks (Flysh Geost, 2016).

Research Methods

Research Equipment

In this study, several pieces of equipment were utilized, including a Crusher, Rod Mill, Flotation tool, hanging sieve, petri dish, mass balance, spoon, brush, 10 ml and 1000 ml beakers, oven, and X-Ray Diffraction (XRD) equipment.

Research Materials

The materials used in this research include 300 grams of gold ore, 30 ml of aloe vera extract, 5 ml of pine oil, 5 ml of Xylene, and 1 liter of distilled water (aquadest).

Research Procedure

The research procedure utilized in this study commences with the preparation of the gold ore sample through crushing using a jaw crusher. The open and close settings are adjusted using a ruler with an open setting size of 0.5 cm and a close setting size of 0.3 cm for primary and secondary crushing. After the crushing of all ore, grinding is conducted using a rod mill until fine particles are obtained, ready for the sieving process. Sieving is carried out using hanging sieves with mesh sizes of 65, 100, and 150. The material from the 150 mesh sieve undergoes the flotation process.

The flotation process is executed using a flotation apparatus by introducing the gold ore obtained from the 150 mesh sieve, totaling 300 grams, and 1 liter of distilled water. Conditioning is then performed by adding 5 ml of pine oil as a frother and 5 ml of xylene as a collector. Subsequently, air is introduced through a compressor with the

Journal of Metallurgical Engineering and Processing Technology, Vol. 4, No. 2
February, 2024
P-ISSN: 2723-6854, E-ISSN: 2798-1037, page 32-40
DOI: https://doi.org/10.31315/jmept

airflow rate controlled. The flotation process takes place for 15 minutes. This testing involves the use of chemical reagents and aloe vera gel extract to enhance the gold mineral flotation ability by improving the stability of the foam or bubbles generated during the flotation process. The concentrate resulting from the flotation process consists of bubbles or foam that rise to the surface, and tailings that precipitate at the bottom of the flotation cell. Subsequently, the concentrate and tailings from the flotation process are dried using an oven to remove their water content. Next, the concentrate resulting from the flotation is weighed for further XRD (X-Ray Diffraction) testing to analyze the types of minerals in the sample, and AAS (Atomic Absorption Spectrophotometry) is performed to determine the elements and their concentrations.

Results of Research and Discussion

Bioflotation Process

The bioflotation process with aloe vera extract begins by preparing the ore to be separated through crushing and grinding. Subsequently, aloe vera extract is added to the flotation cell. The slurry is then stirred using a flotation machine for a specific duration to ensure thorough mixing of the aloe vera extract with the ore, from the conducted bioflotation process, concentrate and tailings are obtained, which are then subjected to analysis using XRD (X-Ray Diffraction). The purpose of this analysis is to identify the minerals separated during the bioflotation process with aloe vera extract. Utilizing XRD provides valuable information for mineral ore processing, contributing to the development of bioflotation technology with aloe vera extract. This, in turn, can enhance the effectiveness and efficiency of this method in mineral ore processing.

Figure 2. *Flotation Process*

XRD Testing

X-Ray Diffraction (XRD) testing can be utilized to identify the minerals present in an ore by directing X-rays onto the sample. X-ray diffraction is a versatile non-

Journal of Metallurgical Engineering and Processing Technology, Vol. 4, No. 2
February, 2024
P-ISSN: 2723-6854, E-ISSN: 2798-1037, page 32-40
DOI: https://doi.org/10.31315/jmept

destructive analytical technique for the identification and quantification of various crystal forms of compounds present in powder and solid samples(Jarot Wiratama et al., 2021).

Diffraction occurs when a wave undergoes refraction or deflection as it crosses a disturbance, such as a crystal lattice. As a result, the wave is scattered in various directions, which can result in signal amplification or attenuation depending on the conditions (Pratapa S, 2009).

X-ray diffraction is one of the methods used to determine the crystallinity of materials, measure particle dimensions and crystal structure parameters. In this technique, X-rays that are elastic are scattered by atoms in a periodic lattice, and this monochromatic scattering produces constructive interference that forms a diffraction pattern (Hastuti E, 2011).

The results of XRD testing can provide valuable information in the processing of mineral ore. This information can be used to determine more effective and efficient separation methods, as well as to optimize the overall ore processing process. XRD testing is conducted using several samples, including the feed consisting of gold ore after undergoing the preparation stages, with the XRD results shown in Figure 3.

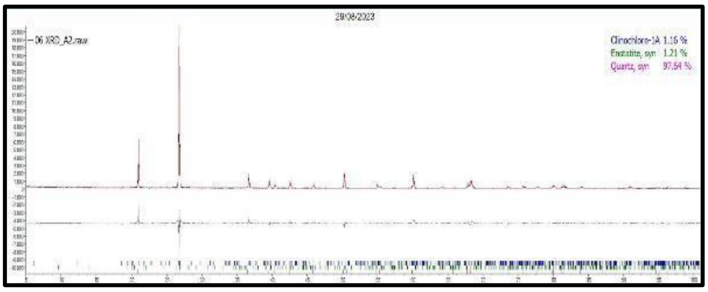

Figure 3. XRD Results of Feed

The XRD results of the feed indicate the presence of minerals, with Quartz (SiO_2) comprising 97.64%, Enstatite syn ($MgSiO_3$) at 1.21%, and Clinochlore-1A ($(Mg,Fe^{++})_5Al(Si_3Al)O_{10}(OH)_8$) at 1.16%. Additionally, XRD testing was conducted on a concentrate sample obtained from the flotation process using chemical reagents, as depicted in Figure 4.

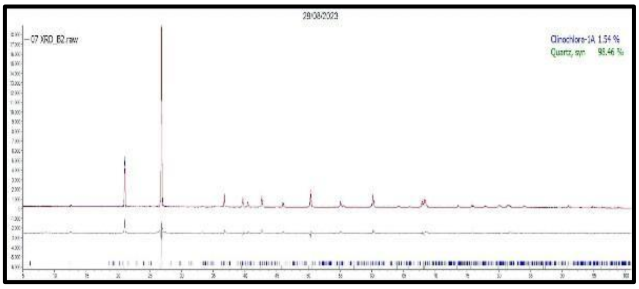

Figure 4. XRD Results of Concentrate with Chemical Reagent

From the XRD results of the concentrate with chemical reagents, Quartz SiO_2 was found to be 98.46%, with Clinochlore-1A at 1.16%. XRD testing for the concentrate

Journal of Metallurgical Engineering and Processing Technology, Vol. 4, No. 2
February, 2024
P-ISSN: 2723-6854, E-ISSN: 2798-1037, page 32-40
DOI: https://doi.org/10.31315/jmept

with aloe vera extract reagent yielded similar results to the chemical reagent concentrate, as shown in Figure 5.

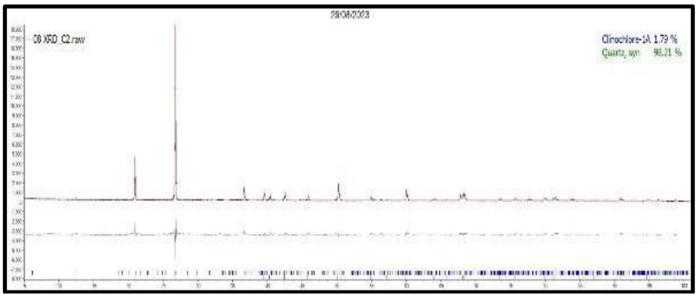

Figure 5. XRD Results of Concentrate with Aloe Vera Extract

The XRD results with aloe vera extract showed that Quartz SiO_2 constituted 98.21%, with Clinochlore-1A at 1.79%. In the tailing sample using chemical reagents, there was an increase in the percentage of Quartz (SiO_2) to 98.95% and a decrease in Clinochlore-1A to 1.05%, as shown in Figure 6.

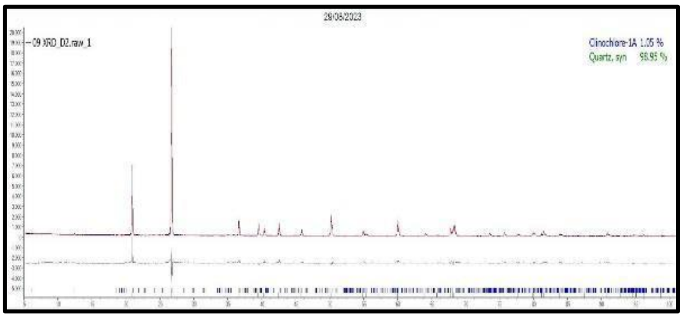

Figure 6. XRD Results of Tailing with Chemical Reagent

In the tailing sample with aloe vera extract, the results showed an increase in Quartz SiO_2, reaching 99.18%, and a decrease in Clinochlore- 1A to 0.82%, as illustrated in Figure 7.

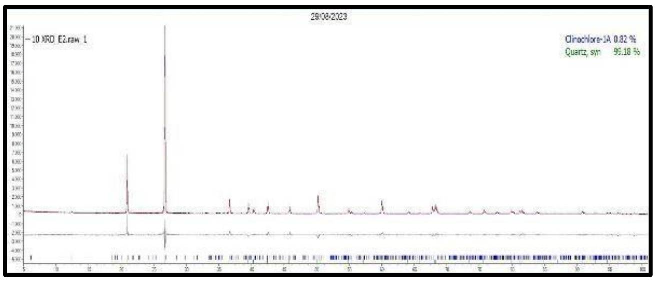

Figure 7. XRD Results of Tailing with Aloe Vera Extract

AAS Testing

Atomic Absorption Spectroscopy (AS) is an instrument in analytical chemistry that uses the principle of energy absorbed by atoms (Gunanjar, 1997). Based on the method (absorption or emission), two types of flame spectrophotometers are known,

Journal of Metallurgical Engineering and Processing Technology, Vol. 4, No. 2
February, 2024
P-ISSN: 2723-6854, E-ISSN: 2798-1037, page 32-40
DOI: https://doi.org/10.31315/jmept

namely: Flame Emission Spectrophotometer (FES) and Atomic Absorption Spectrophotometer (AAS) (Underwood A, 1986).

Atomic absorption spectroscopy is used to analyze the concentration of analytes in a sample. Electrons in the atom will be excited to higher orbitals in a short time by absorbing energy (radiation at certain wavelengths). Atomic absorption spectroscopy consists of various components namely: Radiation source (hallow cathode), Atomizing system (atomizer), Atomizing system (atomizer), Monochromator, Photo detector (photomultiplier tube), Read out (Sumar, 1994).

Results of the AAS analysis using 5 samples, including gold ore used as flotation feed, concentrate and tailings from bioflotation using aloe vera extract reagent, concentrate and tailings from the flotation process with chemical reagents, are presented in Table 1.

Table 1. Results of AAS Analysis

Sample	**Gold Content (ppm)**
Feed (F)	3,94
Aloe Vera Concentrate (C)	10,57
Aloe Vera Tailing (t)	0,92
Chemical Reagent Concentrate (C)	10,11
Chemical Reagent Tailing (t)	1,89

From the AAS analysis data that has been carried out, it can be seen the gold content of several samples that have been tested. In the feed without the flotation process, the gold content obtained is 3.94 ppm, the results of the concentrate using aloe vera reagent the gold content obtained is 10.57, in the flotation tailings with aloe vera reagent the gold content contained therein is 0.92 ppm. While flotation using chemical reagents, the gold content contained in it is 10.11 ppm while in the tailings it is 1.89 ppm. Allowing the calculation of % recovery from the bioflotation results using aloe vera extract reagent and without aloe vera extract reagent or with chemical reagents. The Au content, initially measured in ppm, is converted to grams/liter to facilitate the calculation of % recovery.

% Recovery with Chemical Reagent

$$\%R = \frac{C(F-t)}{F(C-t)} x\ 100\%$$

$$= \frac{0{,}01.\,(0{,}0039 - 0{,}00188)}{0{,}0039(0{,}01 - 0{,}00188)} x\ 100\%$$

$$= 63{,}78\%$$

Journal of Metallurgical Engineering and Processing Technology, Vol. 4, No. 2
February, 2024
P-ISSN: 2723-6854, E-ISSN: 2798-1037, page 32-40
DOI: https://doi.org/10.31315/jmept

% Recovery with Aloe Vera Extract

$$\%R = \frac{C(F-t)}{F(C-t)} x\ 100\%$$

$$= \frac{0{,}0106.(0{,}0039 - 0{,}00188)}{0{,}0039(0{,}0106 - 0{,}00009)} x\ 100\%$$

$$= 84{,}06\%$$

The percentage recovery from the bioflotation results with the addition of aloe vera extract reagent is 84.06%, while without the addition of aloe vera extract reagent, it is 63.78%.

Conclusion

In the bioflotation process, the use of aloe vera extract can increase the percentage of valuable minerals in the concentrate while reducing the percentage of impurity minerals in the tailings. The AAS analysis results show a % recovery of 84.06% with the addition of aloe vera extract and 63.78% without the addition of aloe vera extract. From the conducted XRD and AAS tests, it can be concluded that the use of aloe vera reagent is highly effective in the flotation process compared to the use of chemical reagents.

References

Abdul Latif. (n.d.). Pembentukan Mineral di Alam Mineral Emas (Au). *Jurnal Teknik Perminyakan, STT-MIGAS Balikpapan*.

Adams, M. D. (2005). *Advances in Gold Ore Processing*. *Elsevier*.

Adji, & Shima Parameswari. (2022). *Optimization Of Coal Quality Improvement Using the Flotation Method*. . *E- Journal of Indonesia Mining and Energy Journal*, *5*(1), 45–49. http://researchgate.net/

Anjar Oktikawati, Cahyo Ady, & Johny Wahyuadi. (2023). Studi Pengaruh Titik Penambahan Sodium Isobutyl Xanthate (SIBX) dan Kecepatan Impeller pada Performa Flotasi Mineral Tembaga. . *Jurnal Rekayasa Material, Manufaktur Dan Energi*. http://jurnal.umsu.ac.id/index.php/RMME

Fadel Sidiq. (2021). *Flotasi Logam Au-Ag Beard Pyrit Recovery*. http://www.id.scribd.com/doc. ment/500367224/Flotasi-Emas-Perak-dari-Bijih-Pyrite

Flysh Geost. (2016, June 4). *Mengenal Emas, Logam Mulia dengan Simbol Unsur Au*. https://www.geologinesia.com/2016/11/mengenal-emas-logam-mulia-dengan-simbol-unsur-au.html

Gunanjar. (1997). Spektrofotometri Serapan Atom. *Diktat Keahlian Analisis Kimia Bahan Bakar Nuklir, Batan,*.

Hastuti E. (2011). *ANALISA DIFRAKSI SINAR X TiO 2 DALAM PENYIAPAN BAHAN SEL SURYA TERSENSITISASI PEWARNA* . https://doi.org/https://doi.org/10.18860/neu.v0i0.2416

Jarot Wiratama, Widowati, & Hari Wiki Urama. (2021). *Karakteristik dan Tipe Mineralisasi Hidrothermal berdasarkan Analisis Makroskopis, Mikroskopis, X-Ray Diffraction (XRD), Athomic Absorbtion Spectrophotometry (AAS) di Wilayah Muara*

Siau, Kabupaten Merangin, Provinsi Jambi. *6*(2), 38–47.

Pratapa S. (2009). *Difraksi Sinar-X untuk Sidikjari dalam Analisis Nanostruktur*. *Prosiding Seminar Nasional Hamburan Neutron Dan Sinar-X . 7*, 1–5. https://digilib.batan.go.id/ppin/kata log/file/1410-7686-2009-1- 0011.pdf

Sumar, H. (1994). Kimia Analitik Instrumen. *IKIP Semarang Press*.

Underwood A, L. (1986). *Analisis Kimia Kuantitatif Edisi Kelima*. Erlangga.

Wahyuningsih Tri, Sanwari, Edy, Chaerrun, & Khadijah Siti. (2017). Bioflotasi Bijih Tembaga : Kadar Meningkat Tanpa Reagen Kimia (Aplikasi Bakteri Mixotrof Pengoksidasi Sulfur). *Seminar Nasional Kebumian XII Fakultas Teknologi Mineral UPN "Veteran" Yogyakarta*.

Widi Astuti, Kusno Isnugroho, Fika Roefiek Mufakhir, Ulin Herlina, & Isti Nurjanah. (2018). Benefisiasi Bijih Emas dan Perak Kadar Rendah Menggunakan Palong dan Metode Flotasi. *Jurnal Rekayasa Proses : Chemical Engineering Department, Faculty of Engineering, Universitas Gajah Mada*, *12*(2), 166–186. https://doi.org/doi.org/10.22146/jrekpros.35483

Zhou. (2012). Process Mineralogy and Application in Mineralogy Processing and Extractive Metallurgy. *International Metallurgical Meeting*.