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# Effect of Leaching Time on Dissolution of Gold Metal (Au) in Gold Ore Deposits by Hydrometallurgical Process

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## SARI

Potensi keterdapatan endapan bijih emas di Indonesia salah satunya ditemukan di Daerah Bolaang Mongondow Provinsi Sulawesi Utara. Penelitian ini merupakan salah satu penelitian awal yang dilakukan untuk mengetahui kandungan logam emas pada endapan bijih tersebut berdasarkan hasil ekstraksi Au menggunakan aqua regia. Diketahui ada beberapa parameter operasi yang menentukan tingkat keberhasilann proses pelindian. Salah satu parameter tersebut adalah waktu pelindian. Rentang waktu pelindian yang digunakan dalam penelitian adalah 5, 10, 20, 60 dan 120 menit. Berdasarkan variasi waktu pelindian yang akan diterapkan pada proses pelindian tersebut nantinya juga akan diketahui seberapa besar massa logam Au yang terlarut. Filtrat hasil pelindian yang diperoleh kemudian dianalisis konsentrasinya menggunakan instrumen AAS (Atomic Absorption Spectrometry). Data hasil AAS tersebut kemudian diolah dengan menggunakan kurva x dan y untuk mendapatkan waktu pelindian optimum dan massa logam Au terlarut diperoleh dengan menggunakan persamaan. Hasil penelitian menunjukkan bahwa waktu yang paling optimal pada proses hidrometalurgi pada endapan bijih emas berada pada waktu 120 menit dengan konsentrasi Au 1,67 mg/L.

**Kata kunci**: Pelindian; emas; aqua regia; konsentrasi Au

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*ABSTRACT*

*One of Indonesia's potential gold ore deposits is found in the Bolaang Mongondow area of North Sulawesi Province. This research is one of the initial studies conducted to determine the metal content of gold in ore deposits based on the results of Au extraction using aqua regia. It is known that several operating parameters determine the success rate of the leaching process. One of these parameters is the leaching time. The leaching time ranges used in the study were 5, 10, 20, 60, and 120 minutes. Based on the variation of the leaching time applied to the leaching process, it will also be known how much mass of dissolved Au metal is. The leached filtrate obtained was then analyzed for its concentration using AAS (Atomic Absorption Spectrometry) instrument. The AAS data were then processed using x and y curves to obtain the optimum leaching time, and the mass of dissolved Au metal was obtained using the equation. The results showed that the optimal time for the hydrometallurgical process in gold ore deposits was 120 minutes with an Au concentration of 1.67 mg/L.*

***Keywords:*** *Leaching; gold; aqua regia; Au concentration*

## INTRODUCTION

The Bolaang Mongondow area is located in the middle of the North Arm of Sulawesi Island, often composed of Neogene magma arcs that can contain economic minerals, so it is necessary to study the potential of this product's mineral resources. Previous research concluded that the study area has a direct Au-Ag mineralization pattern with moderate to high sulfidation degrees. Several previous studies around the research site in the Bolaang Mongondow Regency have been carried out, including an inventory and assessment of metallic minerals by the Geological Resource Center of Lolayan Regency, a study of geological deposits and detailed geological descriptions as well as a high sulfide gold mineralization system in Lolayan District (Harjanto, etc., 2016).

Gold, the most malleable or ductile metal, is considered precious because of its texture, density, and high melting point (Boyle, 1979). Gold is extracted separately from gold ore. Currently, gold separation methods widely used for industrial-scale gold development are the cyanide and amalgamation methods (Steele, 2000). Cyanidation is a selective process by cyanide acid where only certain metals can be dissolved, such as Au, Ag, Cu, Zn, Cd, and Co (Guzman, 1999). Amalgamation is the process of binding gold metal from ore using mercury (Widodo, 2008). Gold processing using cyanidation and amalgamation methods harms water and sediment quality around the processing site (Lutvi, 2009). The gold dissolution process can be carried out in various ways, such as using chemical solutions, one of which is aqua regia. Aqua regia, in particular, has been used as the most preferred sample preparation method because it can process various samples since the Middle Ages (Marsden and House, 2006). The performance of the mixed acid solution is very much in line with the criteria for elemental geological materials analysis, such as wide commercial availability, strong oxidizing ability to bring metals into solution, and relatively low cost. One of the many analytical applications

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developed historically and is still a common and effective method in current operations because of its use in extracting precious metals such as silver and gold and strategic metals from rocks and ores in wet dissolution processes (Chao and Sanzolone, 1992).

Aqua regia can be used as a leaching agent (Tuncuk et al., 2012). The chemical solution has a very high ability as an oxidizing agent because nitrosyl chloride and chlorine are active agents due to the reaction between $HNO_3$ and HCl. Due to its very high oxidizing power, aqua regia can dissolve almost all metals, including precious metals such as Au, Pt, Pd, and others that are refractory (heat resistant) (Trisunaryanti et al., 2002). This solvent effectively dissolves gold metal (Tuncuk et al., 2012).

Park (2008) studied the separation of aqua regia solvent from the waste printed circuit (WPCB), with a gold recovery rate of 93%. Still, it is not known whether aqua regia can be used to separate gold directly from the source rock. Therefore, this study was conducted to determine the reaction of Au extraction in the hydrometallurgical process using aqua regia media in gold ore deposits and the optimum time for the leaching process to the obtained Au concentration results in the amount of Au mass dissolved at each Au concentration in the sample.

## METHODS

The data collected to meet the research requirements consisted of data on Au concentration in the sample and mass weight of dissolved Au in the sample. The sample was obtained from gold ore deposits in Loyalan District, Bolaang Mongondow Regency, North Sulawesi.

### Making Aqua Regia Solution

Aqua regia ($HNO_3$ + HCl) acts as a solvent for the leaching process. Aqua regia is made by mixing a solution of concentrated nitric acid ($HNO_3$) and concentrated hydrochloric acid (HCl) in a specific ratio. If used separately, $HNO_3$ and HCl solutions cannot react with gold, so the two acidic solutions must be mixed to dissolve the gold. The two acidic solutions play different parts in the gold dissolution process (Rofika and Rachmanto, 2018).

### Experimental

Gold ore samples from the field were then prepared at the Mineral Processing Laboratory of the Mining Engineering Study Program, FTI UMI. The stages of sample preparation can be seen in Figure 1.

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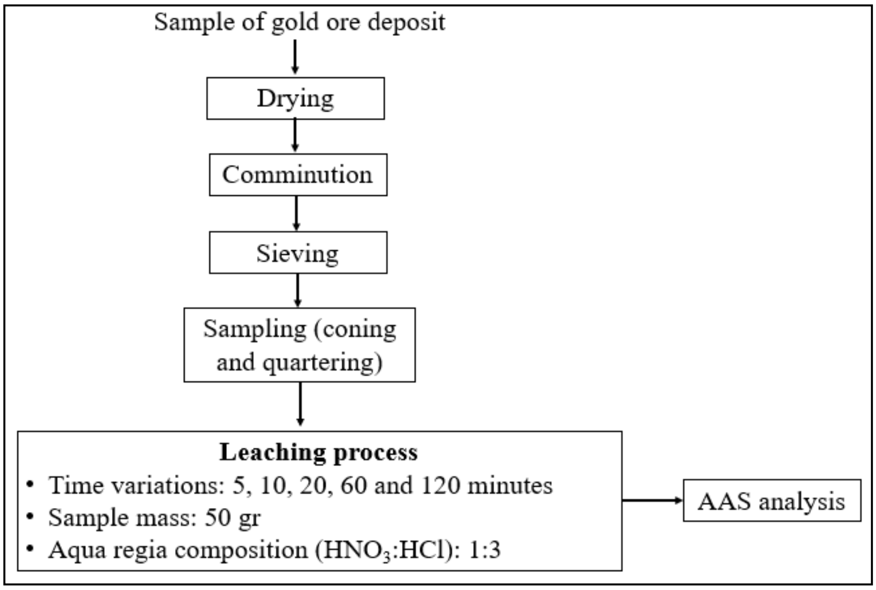


**Figure 1.** Research design

The leaching process was carried out at the Basic Chemistry Laboratory of FTI UMI. The flow chart of the leaching process can be seen in Figure 2. The stages of the leaching process begin by inserting 100 g of sample and 15 ml of aqua regia solution into a 250 ml beaker. The leaching process was carried out for 5 minutes at room temperature. After that, it was allowed to stand for 5 minutes and filtered to separate the solution from the residue. The filtered filtrate was then diluted using distilled water. After that, the filtrate was analyzed using AAS and obtained data in the form of the concentration of Au content contained in each filtrate. The gold ore leaching process was carried out to see the amount of Au concentration and dissolved Au mass contained in the ore before further processing. The mass of dissolved Au can be determined using the equation:

$$\text{Mass of dissolved Au} = \frac{C.P.V}{1000}$$

Where C concentration of Au is the result of analysis with AAS (mg/L), P is the dilution factor, and V is the volume of the mother liquor (L) (Vogel, 1979).

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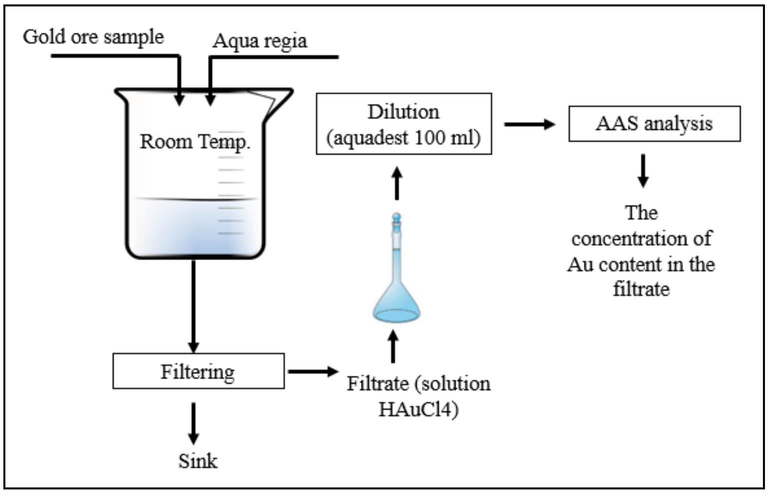


**Figure 2.** Design of leaching process

## RESULTS

Based on the results of AAS laboratory tests carried out on samples of gold ore deposits after leaching using aqua regia, Au concentrations were obtained, which can be seen in Table 1.

**Table 1.** Effect of leaching time on Au concentration

| Leaching time (minutes) | Sample mass (gr) | Particle size (μm) | Aqua regia composition $HNO_3 : HCl$ | Au concentration (mg/L) | Mass of dissolved Au (gr) |
|---|---|---|---|---|---|
| 5 | 50 | 74 | 1 : 3 | 1.32 | 0.000185 |
| 10 | 50 | 74 | 1 : 3 | 1.23 | 0.000172 |
| 20 | 50 | 74 | 1 : 3 | 1.35 | 0.000189 |
| 60 | 50 | 74 | 1 : 3 | 1.46 | 0.000204 |
| 120 | 50 | 74 | 1 : 3 | 1.67 | 0.000234 |

As shown in Table 1, processing the dissolved Au mass data produced different results based on the respective Au concentrations in the sample. The amount of dissolved Au is mainly influenced by the amount of Au concentration obtained previously with the AAS device. The mass of dissolved Au obtained is directly proportional to the concentration of Au produced.

The optimum dissolution time is determined by making a curve between the concentration of gold in the dissolving solution and the leaching time. The leaching time variations used in this study were 5, 10, 20, 60, and 120 minutes.

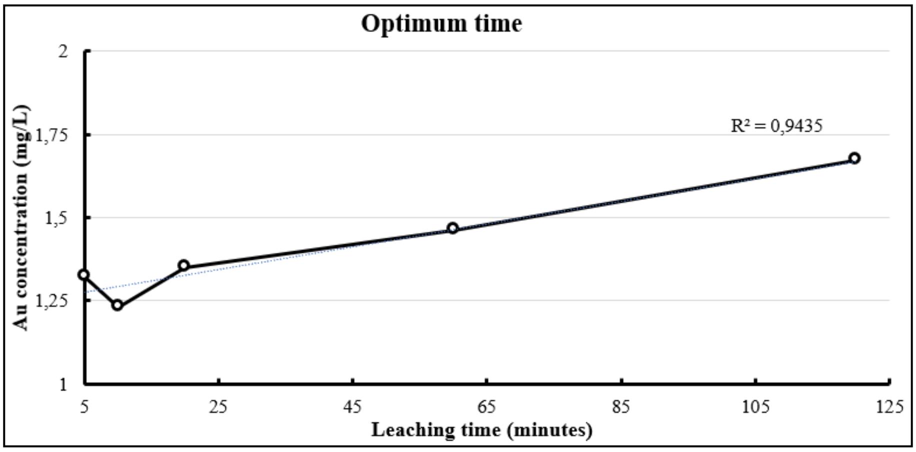


**Figure 3.** Effect of leaching time on Au concentration

Figure 3 shows that the length of leaching time affects the amount of dissolved gold metal and the concentration of Au obtained when tested on the AAS instrument. The longer the dissolution process, the larger the Au measured amount and vice versa. The curve in Figure 3 shows that time affects the gold concentration obtained. This can be proven by the coefficient of determination (R2) on the leaching time relationship curve with the amount of Au concentration of 94%. In this case, only 6% of things other than washing time affect the achieved Au concentration. The dissolved Au concentration can be increased and decreased due to the stability of the aqua regia itself. Aqua regia is a strong and corrosive oxidizing agent. Based on the curve in Figure 3, the optimal time for leaching gold ore deposits with aqua regia to obtain the best gold grade is 120 minutes. Because at that time, the leaching produced a good amount of Au concentration of 1.67 mg/L and a mass of 0.000234 gr dissolved Au.

The decrease or increase in the measured Au content may also be due to the more acidic solvent used. Using too concentrated acid can also interfere with the analysis of AAS. If the concentration is too acidic, the concentration of the analyzed sample will decrease or increase from its actual value. In addition, the possibility of concentrated aqua regia reacting with other metals such as iron and copper is also responsible for the reduced and reduced Au concentrations obtained (Muhammad et al., 2020).

## CONCLUSION

Based on research, data processing, and discussion in the context of writing this report, it can be concluded that the optimum leaching time was obtained at 120 minutes of the leaching process with an Au concentration of 1.67 mg/L and a dissolved Au mass of 0.000234 gr.

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