PROCEDINGS
XIX - MINERAL PROCESSING CONGRESS

(In memory of Prof.Dr. Shyqyri Kelmendi)

MITROVICE, 28-31 MAY 2023

XIX MINERAL PROCESSING CONGRESS
(IN MEMORY OF PROF.DR. SHYQYRI KELMENDI)

EDITED BY

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19th - BALKAN MINERAL PROCESSING CONGRESS IN KOSOVO

Since 1973, when the first Balkan Mineral Processing Congress was held in Bulgaria, this Congress meets regularly every 2 years, in different countries of the Balkans. The Congress is held at the initiative of Balkan Academy of Sciences for Mineral Processing Technology, and the organizers are the International Scientific Committee appointed by the Academy and the National Organizational Committees - created by host countries.

At the regular meeting of BASMT and the Scientific Committee of the Balkan Congress of Mineral Processing, on November 12, 2021, Kosovo was voted and took over the organization of the XIX Balkan Congress of Mineral Processing, which will be held on May 29 - 30, 2023 According to this decision, the organization of the Congress has been entrusted to him"Isa Boletini" University in Mitrovica (UIBM). and the Geoscientific Institute for Mineral and Waste Processing, Energy and Environment (IGJPMMEM) in Pristina

Congress participants will be accommodated in the prestigious hotel in Mitrovica - Palace Hotel & Spa. The Plenary Session of the Congress and the specialized sessions will take place in the halls of the Palace.

To ensure the appropriate financial and institutional support of the XIX Balkan Mineral Processing Congress, the Chairman of the Local Organizing Committee Prof. Dr. Naser Peci and Dr. Habib Basholli, are in preliminary consultation with:

1. Relevant institutions of the Republic of Kosovo:
- Ministry of Economy,
- Ministry of Industry,
- Ministry of Environment and Spatial Planning,
- Ministry of Education, Science and Technology,
- Ministry of Transfers and Finances, and
- Office of the Prime Minister of the RKS;

2. Scientific and professional agencies and institutions:
a. Academy of Sciences and Arts of Kosovo (ASHAK),
b. Public and private universities in Kosovo;
c. Independent Commission for Mines and Minerals (KPMM),
d. Geological Service of Kosovo;
e. NGOs in the field of environmental protection and other fields that communicate with mines and minerals;

The preliminary consultations that will take place during the months of July and August 2022, aim to achieve general support for the successful organization of this important scientific event in our country, to achieve proper awareness and to open the way and opportunities for ensuring adequate financial coverage.

MAIN TOPIC OF CONGRESS

"NEW APPROACHES IN THE APPLICATION OF MINERAL PROCESSING"

28-31 May, MITROVICE, KOSOVA REPUBLIK

SUB TOPICS OF CONGRESS:

1. New technologies of mineral treatment and processing :
2. Contemporary design of the flotation process
3. Modeling, optimization and control in Mineral Processing systems
4. Crushing, milling and classification (SAG, AG, HPGR)
5. Flotation: theoretical and practical approach, reagents and industrial application;
6. Reprocessing of industrial waste, especially - tailings retreatment;
7. Processing of base metals ores and precious metals;
8. New industrial projects and fate of Lignite;
9. Operations and management of mineral processing plants
10. Economy of Mineral Processing and recovery rate;
11. Sampling procedures and confidence of analyzes;

USING MICROCALORIMETRY TO DETERMINE THE ENERGETICS OF SURFACE PHENOMENA OCCURRING IN THE FLOTATION PROCESS AND RELATING THIS TO FLOTATION PERFORMANCE

Cyril T O'Connor
Centre for Minerals Research, Department of Chemical Engineering, University of Cape Town.

Abstract

Microcalorimetry is an important experimental method to quantify the reactions occurring between a solid material and reagents adsorbing at the surface. In the case of flotation which is arguably the most important process used to beneficiate mineral ores the surface reactions occurring between a mineral and water or reagents such as collectors are measured as the enthalpy of immersion or adsorption respectively using microcalorimetry. Although there is significant literature on the determination of such values in many solid-liquid systems. However, in the case of flotation, such measurements have mostly been carried out as microcalorimetric studies and no attempts have been made to relate the enthalpies measured to the ultimate flotation performance of the mineral under investigation. This paper reviews the literature in this regard and attempts to show how such measurements may be related to the flotation behaviour of the mineral. Such studies may have significant overall implications for flotation research.

50 YEARS OF PROGRESS TOWARDS ENVIRONMENTAL FRIENDLY AND THE SUSTAINABLE EXTRACTION OF GOLD

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Abstract

A significant indicator of the direction that sustainable gold mining and extraction is evolving is a review of the technologies being employed in the development of the new large gold mines. Also, gold mining projects within the European Union have been reviewed. During the past fifty years an ever-increasing awareness of the concepts of sustainable mining has developed. In the seventies most of the gold produced used extraction methods based on cyanide chemistry. Many alternative lixiviants have been proposed and studied during the past fifty years.

During the past half-century gold mining has become more sustainable and environmentally friendly, not through the change of lixiviants; but through better process control, improved mineral processing techniques (especially comminution and flotation), and sounder waste disposal.

Reagent use practices are only part of the continued progress in the sustainable extraction of gold technologies. Improved conservation of water and energy in the processing, the obviation of Green House Gases in the mining and milling, and improved waste disposal practices have aided the practice of gold mining and extraction become more sustainable and environmentally friendly during the past half-century. Further improvements will be continued in the future.

Contents

HEAVY METALS REMOVAL FROM SYNTHETIC OBTAINED ACID MINE DRAINAGE USING NEUTRALIZING AGENTS

Afrodita Zendelska[1], Adrijana Trajanova[2], Mirjana Golomeova[1], Blagoj Golomeov[1], Dejan Mirakovski[1], Nikolinka Doneva[1], Marija Hadzi-Nikolova[1]*

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Abstract

Generally, heavy metals can be removed from acid mine drainage by precipitation and sorption using neutralizing agents. The choice of the most effective neutralizing agent for acid mine drainage treatment depends on several things, such as: consu mption of neutralizing agent, speed of pH achievement and removal of heavy metals from AMD.

Several neutralizing agents, including $BaCO_3$, Na_2CO_3, NaOH, KOH, K_2CO_3, MgO, $CaCO_3$ and $Ba(OH)_2$, are explored in this study in order to remove heavy metals from acid mine drainage. The experiments are performed in laboratory conditions using multi-component synthetic aqueous solution with same initial concentration (10 mg/l) of each ion, such as Cu, Mn, Zn, Fe and Pb and initial pH value of 1.9. Comparison of studied neutralizing agents for heavy metals removal from aqueous solutions shown that the most effective neutralizing agent for heavy metals removal from multi-component aqueous solution is MgO, while the lowest efficiency is obtained with Na_2CO_3.

The percentage of heavy metals removed from aqueous solutions increases along with rising pH values. The high removal is obtained at pH 12 for all studied heavy metals and almost 80-82% removed of Pb, Fe and Cu, while almost 74% of Zn and Mn. The series for heavy metal removal from multi-component aqueous solution by neutralizing agents are also presented.

Keywords: AMD; neutralization; active treatment; soda ash; caustic soda; limestone; hydrated lime.

INTRODUCTION

Acidic mine drainage is an environmental pollutant of major concern in mining regions throughout the world. The oxidative dissolution of sulphide minerals in the presence of water and oxygen gives rise to these acidic, metal laden waters. The high acidity of acid mine drainage and the large amounts of dissolved heavy metals, generally make acid mine drainage extremely toxic to most living organisms [1].

The removal of heavy metals from the acid mine drainage can be accomplished by a variety of techniques. The most common method of treating acid mine drainage is active treatment, which includes the addition of alkaline minerals-neutralizing agents [2] to precipitate metals by conventional methods such processes as coagulation, precipitation, ion-exchange, electrochemical methods, membrane processes, extraction, adsorption among other things [3].

These methods are typically used to treat acid mine drainage with very high levels of acidity, while being capable of adjusting to the varying geo-chemical properties. However, active treatment is limited by its cost and sludge generation, making it unsustainable in the long run [4].

In comparison, passive treatments are considered to be more cost-effective to use in a closed and abandoned mine site due to the stable chemistry at these mine sites as well as the accessible land for remediation systems [5, 6].

Regardless of which acid mine drainage treatment process is used, a neutralization process must be used to raise the water's pH above 7.0, using alkaline reagents, before discharge. The materials that are often used to generate alkalinity are limestone, hydrated lime, lime, quicklime, magnesite, periclase, brucite, dolomite, fly ash, soda ash, caustic soda, and ammonia [7-9].

Also waste by-products were used as an alkalinity-generating material such as eggshell waste [10], wood ash [11], phosphatic waste rock [12], concrete aggregate [13], and serpentinite found in mining waste rock that belongs to the serpentine group of minerals considered as alkaline-rich [7].

The main goal of this paper was to investigate the efficiencies of the neutralizing agents such as $BaCO_3$, Na_2CO_3, NaOH, KOH, K_2CO_3, MgO, $CaCO_3$, and $Ba(OH)_2$ in order to remove heavy metals (Cu, Fe, Mn, Pb, and Zn) from a multi-component synthetic acidic aqueous solution and the possibility of their application in acid mine drainage treatment.

METHODOLOGY

The multi-component synthetic acidic aqueous solution with concentration of 10 mg/L of Cu, Mn, Zn, Fe, and Pb ions were prepared in the laboratory conditions using distilled water and standard certified solutions from Perkin Elmer in the form of nitrates of copper, iron, manganese, zinc, and lead. Due to the content of 2% nitric acid in the standard certified solutions, the initial pH value of the multi-component synthetic aqueous solution was 1.90.

To control and monitor the pH value, a pH 1000L VWR was used and combined with electrode pH enomenal 221 (ecn: 662-1161). Measurement of metal concentration was performed using atomic absorption spectroscopy.

The instrumental technique used was an AAnalyst 400 Perkin Elmer atomic absorber. The neutralizing agents prepared in concentrations of 0.025 mol/L were added with a 10 mL A class pipette in a 100 mL of the multi-component synthetic aqueous solution using a 300 mL glass. The neutralizing agents were loaded continuously, adding 10 mL at a time until a constant pH was achieved in the multi-component synthetic aqueous solution. The solution was mixed using a magnetic stirrer, model: As One HS-4DC /1-262-01 Battery Operated Starler. The neutralizing agents used in the experiments were $BaCO_3$, Na_2CO_3, NaOH, KOH, K_2CO_3, MgO, $CaCO_3$, and $Ba(OH)_2$.

RESULTS AND DISCUSSION

A comparison of the efficiency of eight different neutralizing agents for the removal of heavy metals from acid mine drainage, such as: $BaCO_3$, Na_2CO_3, NaOH, KOH, K_2CO_3, MgO, $CaCO_3$ and $Ba(OH)_2$ is presented in this paper. The experiments were performed using a multicomponent synthetic aqueous solution with an initial concentration of 10 mg/l of Cu, Mn, Zn, Fe and Pb ions and an initial pH value of 1.90 and a neutralizing agent concentration of 0.025 mol/L. Table 1 shows the results for the maximum pH value that can be achieved with each of the studied neutralizing agents, as well as the time for its achievement expressed in seconds. According to the achieving the highest pH value, $Ba(OH)_2$ was found to be the neutralizer that achieved the highest pH value, and $CaCO_3$ was the neutralizer that achieved the lowest pH value of the solution. The order from highest to lowest pH is as follows [14]:

$$Ba(OH)_2 > NaOH > KOH > K_2CO_3 > Na_2CO_3 > MgO > BaCO_3 > CaCO_3$$

According to the speed of achievement maximum pH value, it is different for all eight neutralizers. $Ba(OH)_2$ was the fastest, while MgO was the slowest. The order from fastest to slowest neutralizing agent is as follows [14]:

$$Ba(OH)_2 > NaOH > K_2CO_3 > KOH > Na_2CO_3 > BaCO_3 > CaCO_3 > MgO$$

NEUTRALIZING AGENTS	TIME FOR ACHIEVEMENT MAXIMUM PH VALUE (S)	MAX ACHIEVEMENT PH VALUE
$Ba(OH)_2$	387.5	12.15
NaOH	733.5	11.99
K_2CO_3	749.0	10.53
KOH	756.0	11.67
Na_2CO_3	1777.0	10.47
$BaCO_3$	2128.5	7.34
$CaCO_3$	2938.5	7.26
MgO	5308.0	9.84

Table 1 Time for achievement maximum pH value

In order to remove heavy metals from aqueous solutions as efficiently as possible, the optimal pH value was found (Figure 1). Almost 80-82% of Pb, Zn, and Cu were precipitated at pH 12, while almost 74% of Zn and Mn were precipitated at pH 12. Additionally, it is clear from Figure 1 that the percentage of heavy metals removed increases along with rising pH values.

The obtained results are inconsistent with those reported by Skousen *et al.* [5]. According to them, the types and amounts of metals in the water heavily influence the selection of an AMD treatment system because the pH required to precipitate most metals from water ranges from pH 6 to 9 (except Fe^{+3}, which precipitates at pH > 3.5) [5]. Ferrous iron converts to a solid bluish-green $Fe(OH)_2$ at pH > 8.5. In the presence of oxygen, Fe^{+2} oxidizes to Fe^{+3}, and $Fe(OH)_3$ forms a yellowish-orange solid (commonly called yellow boy), which precipitates at pH > 3.5. In oxygen-poor AMD, where Fe is primarily in the Fe^{+2} form, enough alkalinity must be added to raise the solution pH to 8.5 before $Fe(OH)_2$ precipitates [5].

Manganese precipitation is variable due to its many oxidation states but will generally precipitate at a pH of 9.0 to 9.5. Interactions among metals also influence the rate and degree to which metals precipitate. For example, Fe precipitation will largely remove Mn from the water at pH 8 due to co-precipitation but only if the Fe concentration in the water is much greater than the Mn content (about 4 times more or greater). If the Fe:Mn ratio is less than 4, Mn is not removed by co-precipitation, and a solution pH of > 9 is necessary to remove it from solution [5].

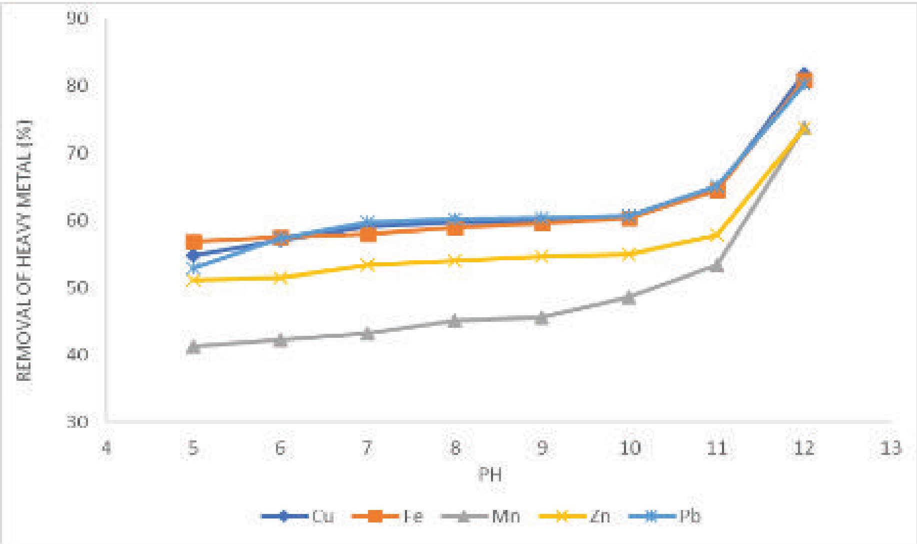

Figure 1 pH ranges for metal precipitation with KOH [14]

The following experiments were conducted with the greatest pH value that could be achieved in accordance with the neutralizing agent utilized because the maximum removal of heavy metals was obtained at the highest pH value. Comparison of the studied neutralizing agents for heavy metal removal from aqueous solutions is shown in Figure 2.

From the results, it can be concluded that the most effective neutralizing agent for heavy metal removal from multi-component aqueous solution is MgO, while the lowest efficiency is obtained with Na_2CO_3 (Figure 2 and Table 2).

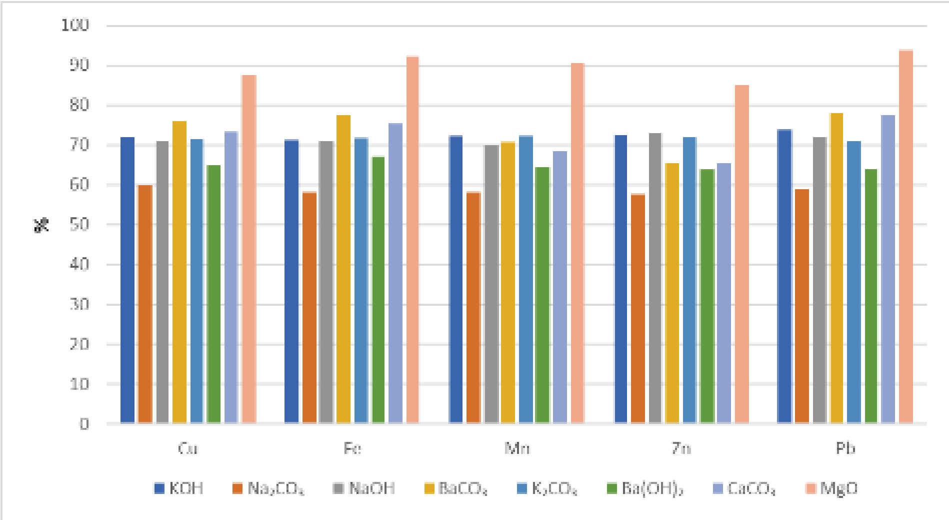

Figure 2 Comparison of studied neutralizing agents for heavy metals removal at lowest neutralizing concentration

According to Skousen et al. [5], caustic soda (NaOH) is often used if Mn concentrations in AMD are high but according to the results obtained in this work, the precipitation of Mn was more effective using MgO, K_2CO_3, KOH, and $BaCO_3$ than NaOH.

Table 2 shows the order of removal of metals by neutralization for each neutralizing agent individually. These series can help in selecting a neutralizer in a situation where the heavy metal content is known.

NEUTRALIZING AGENTS	A SERIES OF HEAVY METAL REMOVAL USING THE APPROPRIATE NEUTRALIZING AGENT
MgO	Pb > Fe > Mn > Cu > Zn
KOH	Pb > Zn > Mn > Cu > Fe
NaOH	Zn > Pb > Fe > Cu > Mn
$Ba(OH)_2$	Fe > Cu > Mn > Pb > Zn
$BaCO_3$	Pb > Fe > Cu > Mn > Zn
$CaCO_3$	Pb > Fe > Cu > Mn > Zn
K_2CO_3	Mn > Zn > Fe > Cu > Pb
Na_2CO_3	Cu > Pb > Mn > Fe > Zn

Table 2 Series of heavy metal removal

From the results shown in Table 2 and Figure 2 it can be clearly concluded that each of the tested neutralizing agents behaves differently in terms of removing heavy metals from the solution.
After obtained results, the possibility of neutralize and remove heavy metals from the water that circu-

lates in the leaching process also were studied. KOH was chosen as the most suitable and effective neutralizing agent because of its speed and high degree of removal of heavy metals.

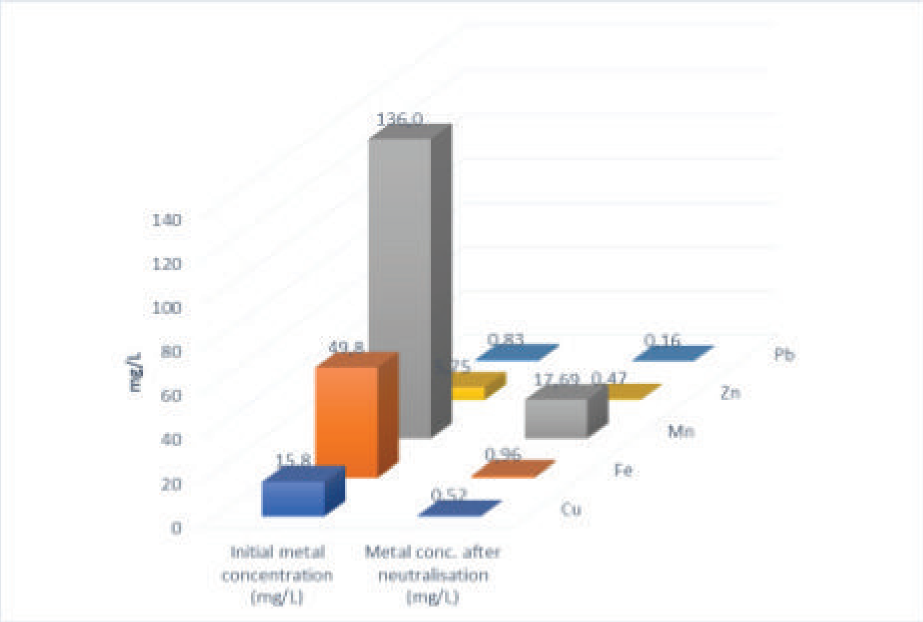

Figure 3 Concentration of metals before and after treatment with a KOH of leaching process water

The obtained results show that after neutralization with 0.025 mol/L KOH, a successful removal of metals was achieved, with a removal percentage of 96.7, 98.1, 87.0, 91.8, 80.7 for Cu, Fe, Mn, Zn and Pb respectively and raising the pH value was from 2.12 to 10.73. Therefore, KOH as well as other neutralizing agents can find application in the case of wastewater generation from the leaching process.

4. CONCLUSIONS

The results of eight studied neutralizing agents, such as: $BaCO_3$, Na_2CO_3, NaOH, KOH, K_2CO_3, MgO, $CaCO_3$, and $Ba(OH)_2$ were compared in order to obtain the most effective neutralizer for the removal of heavy metals from acid mine drainage. The maximum pH that can be achieved with each of the neutralizers studied is given by the following series:

$$Ba(OH)_2 > NaOH > KOH > K_2CO_3 > Na_2CO_3 > MgO > BaCO_3 > CaCO_3$$

while the speed of achieving the maximum pH value is given below:

$$Ba(OH)_2 > NaOH > K_2CO_3 > KOH > Na_2CO_3 > BaCO_3 > CaCO_3 > MgO$$

The percentage of heavy metals removed from aqueous solutions increases with increasing pH. The highest removal is obtained at pH 12 for all investigated heavy metals.

The comparison of the studied neutralizing agents for the removal of heavy metals showed that the most effective neutralizing agent for the removal of heavy metals from a multi-component aqueous solution is MgO, while the lowest efficiency was obtained with Na_2CO_3.

The results of the studied possibility of neutralize and remove heavy metals from the water that circulates in the leaching process using KOH shows that KOH as well as other neutralizing agents can find application in the case of wastewater generation from the leaching process.

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