Tuijin Jishu/Journal of Propulsion Technology
ISSN: 1001-4055
Vol. 45 No. 1 (2024)

Analysis of Manganese (Mn) Levels in Barite Minerals by Atomic Absorption Spectrophotometry

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ABSTRACT

This research was carried out in two locations, namely the research laboratory at FMIPA UNY for sample decomposition, and absorbance measurements using Atomic Absorption Spectrophotometry were conducted in the analytical chemistry laboratory at FMIPA UGM. The aim of this research was to determine the percentage of manganese content in barite minerals from the Plampang, Kokap, Kulonprogo area. It employed a quantitative and qualitative research approach (mixed methods). The research subjects comprised three types of barite rocks collected from the hamlets of Plampang, Kokap, and Kulonprogo. The research objective was to determine the manganese content in these barite rocks. Barite rock decomposition was achieved using aqua regia. Both qualitative and quantitative analyses were conducted using the Atomic Absorption Spectrophotometry method, with absorbance measured at a wavelength of 279.6 nm. The standard solution utilized was prepared from Mn(NO3)2·4H2O crystals dissolved in water. The manganese content in stone A was determined to be (0.2573 ± 0.1488)%, while no detectable manganese content was found in stone B. Stone C exhibited a manganese content of (0.6371 ± 0.0975)%.

Keywords: Content, Manganese, Barite Mineral, Spectrophotometry, Atom

1. INTRODUCTION

Kulonprogo Regency is situated in the westernmost part of the Yogyakarta Special Region Province, bordered by Sleman and Bantul regencies to the east, Magelang regency (Central Java) to the north, Purworejo regency (Central Java) to the west, and the Indonesian ocean to the south (Triwahyuni et al., 2017). Kulonprogo features a coastal plain in the south, undulating hills in the middle and east, as well as steep hills and mountains in the west and north, known as Menoreh Hills (Santosan & Adji, 2018). Meanwhile, the study area encompasses Plampang, Kokap, and Kulonprogo. Barite rocks in this region are underutilized due to a lack of awareness among local residents regarding their specific benefits.

In general, barite (BaSO4) contains a mixture of elements including chromium (Cr), calcium (Ca), radium (Ra), manganese (Mn), and lead (Pb), which form compounds with the same crystalline structure. Barite impurities may include iron oxides, clays, and organic elements, contributing various colors to the crystals, which are naturally white or gray (Purnawati, 2022).

Manganese is a naturally occurring metal often found alongside iron in the Earth's crust. It dissolves in oxygen-poor groundwater and surface water, leading to manganese concentrations in water reaching milligrams per liter (Aini, 2022). Under certain conditions, when exposed to oxygen, manganese can form insoluble oxides and precipitates, causing aesthetic issues in water. Moreover, manganese is extensively used in the metallurgical and chemical industries (Iswandi, 2022).

In the metallurgical industry, manganese serves as a fundamental material for producing strong, durable steel and bronze for ship propellers, which dampens vibrations and noise. Additionally, manganese is utilized in iron casting (Shidik & Sidiq, 2022). In the chemical industry, it is employed in uranium ore leaching, welding rods, dye production, fertilizer manufacturing, pharmaceuticals, ceramics, among other applications. Given the critical role of manganese in various industrial processes, it is imperative to investigate its presence in barite minerals. This study employs atomic absorption spectrophotometry (AAS) as the analytical method.

2. METHOD

This research employs a mixed methods approach, incorporating both quantitative and qualitative methodologies. Quantitative and qualitative research are distinct methodologies that can be used independently or in conjunction with each other. Mixed methods combine elements of both approaches within a single study to provide a more comprehensive understanding of the phenomenon under investigation (Mufidah et al., 2024).

The study subjects consisted of three samples of barite rocks collected from Plampang Hamlet, Kalirejo Village, Kokap District, Kulonprogo Regency, designated as "stone A," "stone B," and "stone C." The objective of this investigation is to assess the levels of manganese in these barite rocks, with calcium levels expressed as a percentage (w/w). The variable examined in this study is the manganese content in different types of barite rocks, expressed as mass percent, indicating the grams of total manganese present in every 10 grams of barite.

Qualitative analysis of manganese was conducted using atomic absorption spectrophotometry at a wavelength of 279.6 nm. The presence of absorption indicates the presence of manganese in the solution. Data analysis techniques employed in this study include constructing a calibration curve of manganese standard solutions, determining correlation and significance tests between variables X and Y, evaluating the linearity of regression lines, determining manganese concentrations in samples, assessing manganese levels in samples, and establishing confidence limits for manganese levels in samples.

3. RESULT

The manganese qualitative test in this study was carried out using atomic absorption spectrophotometry at a wavelength of 279.6 nm. This shows the presence of manganese levels in barite rocks found in Kulonprogo Snapper. The readings with an atomic absorption spectrophotometer at a wavelength of 279.6 nm obtained absorbance from a standard solution and snippets can be seen in the following table:

Table 1. Absorbance Data of Manganese Standard Solution and Sample Solution

Absorption data (A) of manganese standard solution		
No	**Solution with Mn concentration (bpj)**	**Absorption**
1	2,00	0,094
2	4,00	0,185
3	6,00	0,259
4	8,00	0,347
5	10,00	0,411
Absorption data (A) snippet solution		
1	Stone A1	0,020
2	Stone A2	0,022
3	Stone A3	0,019
4	Stone B1	-
5	Stone B2	-
6	Stone B3	-
7	Stone C1	0,036
8	Stone C2	0,037
9	Stone C3	0,035

In this experiment, the price of a= 0.041257142 and b= 0.009714285, so the regression line equation is Y=0.041257142X +0.009714285. The results of determining the linear regression line equation can be seen in the following table:

Table 2. Determination of Standard Solution Regression Line Equation Based on Standard Solution Concentration (X) and Absorption (Y) Data

No	X	Y	X2	Y2	XY
1	2	0,094	4	0,008836	0,188
2	4	0,185	16	0,034225	0,740
3	6	0,259	36	0,067081	1,554
4	8	0,347	64	0,120409	2,776
5	10	0,411	100	0,168921	4,11
Σ	30	1,296	220	0,399472	9,368

The results of determining the graph of the relationship between concentration vs absorbance can be seen in Figure 1 below:

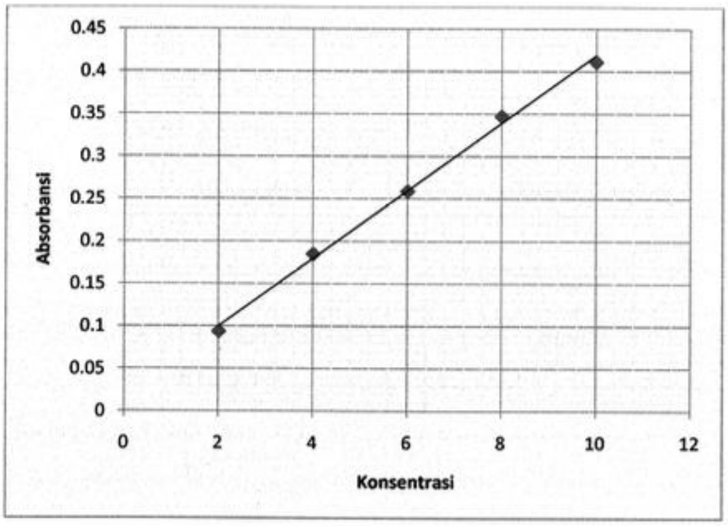

Figure 1. Graph of the relationship between absorbance vs concentration of manganese standard solutions

To determine whether there is no correlation between absorption (absorbance) and the concentration of a standard solution of manganese, it is tested with the moment product correlation formula:

$$Rxy = \frac{\Sigma xy}{\sqrt{(\Sigma x^2)+\Sigma y^2}}$$

From the calculation results, the price of Rxy is 0.998386751. The rtable price at 1% significance teraf is 0.959. Since xIy counts > r table, there is a significant correlation between the concentration (X) and absorption (Y) of the standard solution.

Table 3. Test calculation summary – F

Source	Jk	db	RJk	F-count
regression	0,119150628	1	0,119150628	1236,733629
residue	0,000385372	4	0,000096343	
total	0,119536000	5	0,119054285	

The F-table price is at a signification level of 1% with db= 1 versus 4 of 21.20, while the F-count price is 642.236. F-count price >F price table, so it can be concluded that the regression line equation is linear. Based on the calculation results, the concentration of the snippet solution is obtained as in Table 4.

Table 4. Manganese Concentration in Snippet Solution

No	Solution	Concentration
1	Stone A1	0,2493
2	Stone A2	0,2978
3	Stone A3	0,2250
4	Stone B1	-
5	Stone B2	-
6	Stone B3	-
7	Stone C1	0,6371
8	Stone C2	0,6613
9	Stone C3	0,6128

Based on the calculation results, the average levels and limits of manganese toughness are obtained in the snippet as in Table 5.

Table 5. Manganese Levels and Toughness Limits of Barite Rock

Footage		Kadar (%)	Average levels	Limits of Resilience
Sample A	A1	0,2493	0,2573%	(0,2573 ± 0,1488)%
	A2	0,2977		
	A3	0,2250		
Sample B	B1	-	-	-
	B2	-	-	-
	B3	-	-	-
Sample C	C1	0,6371	0,6371%	(0,6371 ± 0,0975)%
	C2	0,6613		
	C3	0,6128		

4. DISCUSSION

The qualitative and quantitative analysis of manganese levels in this study was conducted using Atomic Absorption Spectrophotometry. Qualitative analysis aimed to ascertain the presence or absence of manganese in the rocks, while quantitative analysis aimed to determine the manganese content.

For qualitative analysis, direct snippet solutions were subjected to atomic absorption spectrophotometry using hollow cathode lamps at a wavelength of 279.6 nm. Absorption in this measurement confirmed the presence of manganese in the snippet solution.

Quantitative analysis involved measuring the absorbance of the snippet solution using the Atomic Absorption Spectrophotometry tool. Manganese levels were determined for three types of barite rock referred to as "stone A," "stone B," and "stone C."

Each type of barite rock exhibited slight differences in physical appearance. "Stone A" appeared slightly shiny and crystal-like in color, "stone B" had a crystal-like appearance with a faint whitish hue, and "stone C" appeared grayish-black. These variations affected the manganese levels in each rock. "Stone A" had an average content of 0.2573%, "stone B" showed undetectable levels, while "stone C" had an average content of 0.6371%. The results indicated that the manganese levels in "stone C" were higher than those in "stone A," likely due to the darker coloration indicating a higher manganese content. Additionally, the color and content influenced the hardness of the rocks, with "stone C" being the hardest, followed by "stone A," and "stone B."

The absence of detectable manganese levels in "stone B" suggests either the complete absence of manganese or its presence at very low levels. According to Bachrawi (1994: 46), economically valuable manganese ore typically contains more than 40% manganese. The three types of rocks observed in this study contained much lower manganese levels than economically valuable manganese ores, indicating that barite extraction may not yield significant benefits during processing.

5. CONCLUSION

Based on the results of the study, it can be concluded that there are significant variations in manganese levels among the stone samples. The average manganese content in rock A is $(0.2573 \pm 0.1488)\%$, while rock B showed undetectable levels, and rock C had an average content of $(0.6371 \pm 0.0975)\%$. These findings highlight substantial differences in mineral composition and manganese content among the three rock samples. Based on the research results, it is recommended that further studies be conducted to investigate manganese levels in barite rocks from other hamlets. Additionally, research should explore alternative decomposition methods and analytical techniques to accurately assess manganese levels. Expanding the scope of research in this manner would provide a more comprehensive understanding of manganese distribution in barite minerals.

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