*International Journal of Engineering and Science Applications*
*Vol 9 Issue 1 2022*
ISSN 2406-9833

**IJEScA**

# Vertical Distribution of Total Sulfur in Coal Seams in Tamalea Village, Bonehau Regency, West Sulawesi Province

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**Abstract**
Sulfur content plays an important role in determining quality and utilization of coal. This study analyzes the total sulfur content in the coal seam, overbunden, and underburden. The aim of the study is to analyses the vertical distribution of total sulfur content in the eight samples (four coal, two overburden and two underburden samples). Coal sampling in this study is done by channel sampling with ply by ply method. The analysis of total sulfur at A and B stations show that the overburden (roof) has total sulfur of 0.20% and 0.23%, the underburden (floor) has total sulfur of 3.85% and 5.80%. The coal sample at the top ply (ply 1) has total sulfur of 0.86% and 1.30%, while the coal at the32 bottom ply (ply 2) has total sulfur of 2.27% and 4.45%. The data shows that the total sulfur content in the bottom ply (ply 2) of coal and underburden (floor) is higher than in the top ply (ply 1) of coal as well as overburden (roof). It can be concluded that the concentration of total sulfur tend to be low (decrease) from the floor (underburden) to the roof (overburden).

*Keywords: Coal; Total sulfur; Overburden; Underburden; Ply by ply; Channel sampling*

## 1. Introduction

Coal is an alternative energy source widely used for steam power plants and other uses. Coal resources are scattered in several regions in Indonesia. The coal samples in this study originated from Tamalea Village, Bonehau Regency, West Sulawesi Province. Stratigraphically the Toraja Formation is a coal-bearing formation in Bonehau Regency. The Eocene Toraja Formation indicates the presence of coal, sandstone and claystone [1].

Sulfur in coal is an important factor in determining coal quality and evaluating coal resources [2, 3]. Sulfur can negatively impact for industry and the environment, such as the formation of acid mine drainage so that the total sulfur content becomes a major consideration in coal utilization [4-8]. Previous study for total sulfur, proximate, and calorific value in Indonesia have been done by some authors [9, 10].

Sulfur content in coal are divided into two categories, namely organic sulfur and inorganic sulfur. Inorganic sulfur present in the form of sulfates, and sulfides, where pyrite and marcasite are sulfide minerals are mostly found in coal [2, 4, 8, 11-15]. Organic sulfur includes mercaptans, disulfides, thioethers, sulfoxides, sulfones, thiophenes, and sulfonates [11].

The presence of sulfur in coal varies widely. Determine the level of sulfur content in coal is classified into four parts: coal with a sulfur content of less than 1% is referred to as coal with low sulfur content. In contrast, coal with a sulfur content of 1% - 3% is referred to as coal with moderate sulfur content. Coal with a sulfur content of more than 3% are referred to as coal with high sulfur content [2, 5, 7, 8, 16-18], but in general, the sulfur content in coal that is often found is around 0.5% - 5%, while the sulfur content with a percentage of 4% - 11% is super high sulfur (SHS) coal, which is coal that is very rich in organic sulfur [2, 19].

The depositional environment also influences the abundance of sulfur in coal. Most coal seams affected by water have moderate to high sulfur content, where sulfate in seawater accumulates and diffuses into the peat during the deposition process [2, 4, 7, 20]. The influence of the depositional environment causes the floor and roof of coal to be one of the carriers of sulfur in coal. This proves many studies regarding sulfur associated with floor (underburden) roof (overburden) of coal that can produce acidic water [4, 5, 7, 21, 22]. This study aimed to determine the vertical distribution of total sulfur content in the coal seam using total sulfur analysis.

## 2. Methodology

Research methods in this study consist of field and laboratory research. Field research is carried out in Tamalea Village, Bonehau Regency, West Sulawesi Province, with two sampling point stations, namely station A and B. Station A is located at coordinates 2°28'15.85"S / 119 °19'39.01"E and station B is situated at coordinates 2°28'32.85"S / 119°20'10.39"E (Figure 1). Sampling process was done by channel sampling method. Sampling process was carried out starting from the roof to the floor of coal seam using ply by ply system. The observation should be concicderated based on the differences in physical conditions both in terms of color and hardness of the coal, roof and floor.

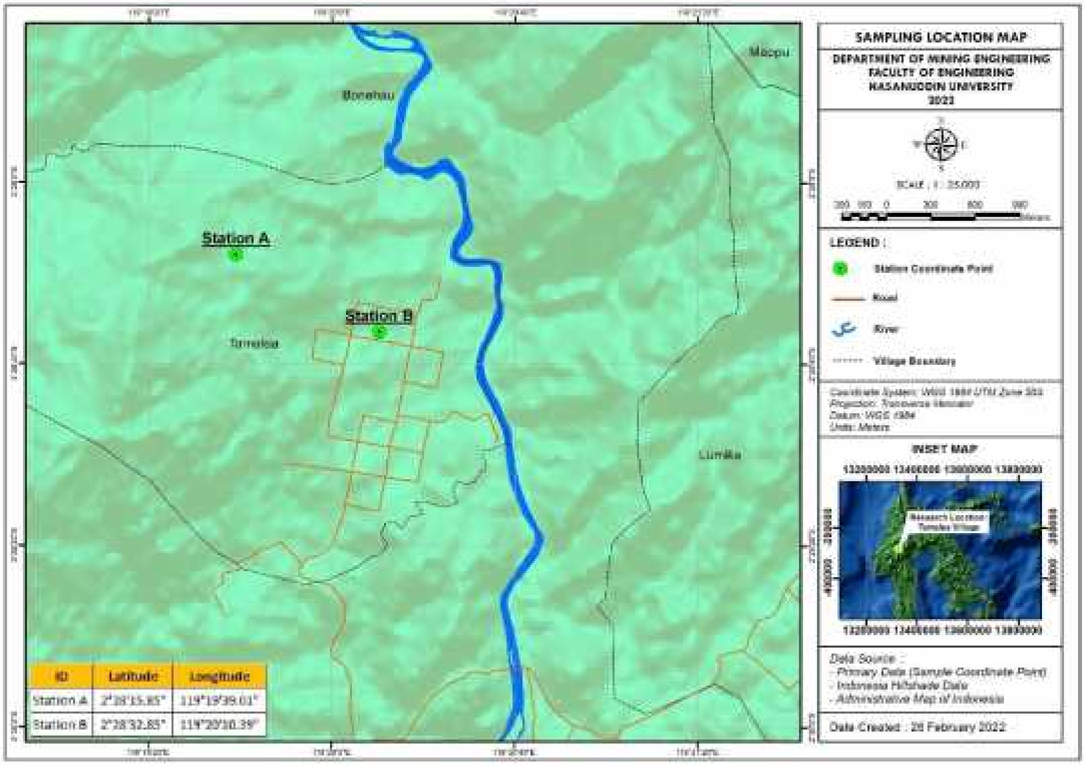


Figure 1. Map of sampling locations for coal, overburden (roof) and underburden (floor) in Tamalea Village, Bonehau Regency, West Sulawesi Province.

In laboratory research, the processing of coal, roof and floor samples is carried out in a size reduction stage using a crusher, then grinding with a ball mill to form the sample into powder, then sieved with a size of 65 mesh (<0.25 mm), then analyzed using an automated LECO SC-344 carbon sulfur analyzer which aims to determine the total sulfur content contained in coal, roof and floor samples. Total sulfur analysis using ASTM D4239-2018 standard [23]. The sample processing was carried out at the Mineral and Coal Analysis Laboratory of PT. SUCOFINDO Makassar.

## 3. Results and Discussion

*A. Coal, overburden (roof) and underburden (floor) Station A*

The results of the field research at station A consisted of four samples consisting of samples overburden (roof), underburden (floor) and two samples of coal. Coal at station A has a coal thickness of about 2 meters, as shown in Figure 2. Macroscopically the coal at station A has a different color, and a different hardness level between the top and the bottom ply of coal, the color on the top ply coal looks brighter compare to the coal at the bottom ply. The bottom ply looks duller, so separating the samples based on these differences is necessary. The results can be distinguished during the analysis, and the distributin of sulfur can be interpreted properly. The sample code BNH01-PL01 represents the top of the coal ply 1, BNH01-PL02 represents the bottom coal ply 2, BNH01-RF is the gray clay rock representing the overburden (roof) and BNH01-FL is also a brownish-gray clay rock representing the underburden (floor) or bedrock.

*B. Coal, overburden (roof) and underburden (floor) Station B*

The results of the field research at station B are not much different from station A which consists of four samples consisting samples of overburden (roof), underburden (floor) and two samples of coal. Coal at station B has a thickness of about 1.60 meters of coal, as shown in Figure 3. Macroscopically the coal at station B has different colors. With different levels of hardness between the top and the bottom ply of coal, the color of the coal at the top looks brighter. In contrast, the bottom ply of the coal looks duller. Based on these differences, it is necessary to separate the samples as at station A, so that the results can be distinguished specifically during the analysis and the distribution of sulfur content can be interpreted


Figure 2. Coal, overburden (roof) and underburden (floor) at Station A

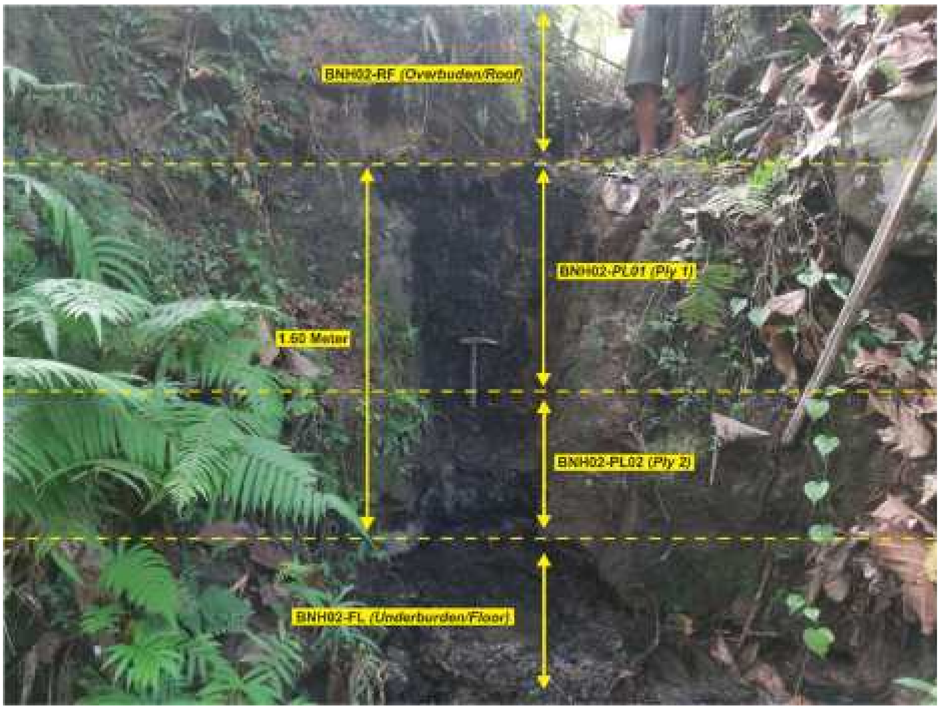


Figure 3. Coal, overburden (roof) and underburden (floor) at Station B

precisely. The sample BNH02-PL01 represents the top of the coal ply 1, BNH02-PL02 represents the bottom coal ply 2, BNH02-RF is a gray clay rock representing the overburden (roof), and BNH02-FL is also a brownish-gray clay rock representing the underburden (floor) or bedrock.

*C. Results of total sulfur analysis in coal, overburden (roof) and underburden (floor) Station A*

Based on the analysis of total sulfur that has been carried out on samples at station A, the total sulfur values are different. The results of the analysis of total sulfur in Table 1 show the percentage of total sulfur BNH01-RF of 0.23%, BH01-PL01 of 0.86%, BNH01-PL02 of 2.27%, and BNH01-FL of 3.85%. Based on the results of the total sulfur analysis shows that the total sulfur tend to be increasing from the roof to the floor as shown in Figure 4. This indicates that the total sulfur distribution in vertical profile from the bottom (floor) to the top (roof) tend to be decreasing. It can be interpreted that the source of sulfur content in coal originited from underburden (floor).

Table 1. Results of total sulfur analysis of coal, overburden (roof) and underburden (floor) for station A

| No | Sample Code | Total Sulfur (%) |
|---|---|---|
| 1 | BNH01-RF | 0.23 |
| 2 | BNH01-PL01 | 0.86 |
| 3 | BNH01-PL02 | 2.27 |
| 4 | BNH01-FL | 3.85 |

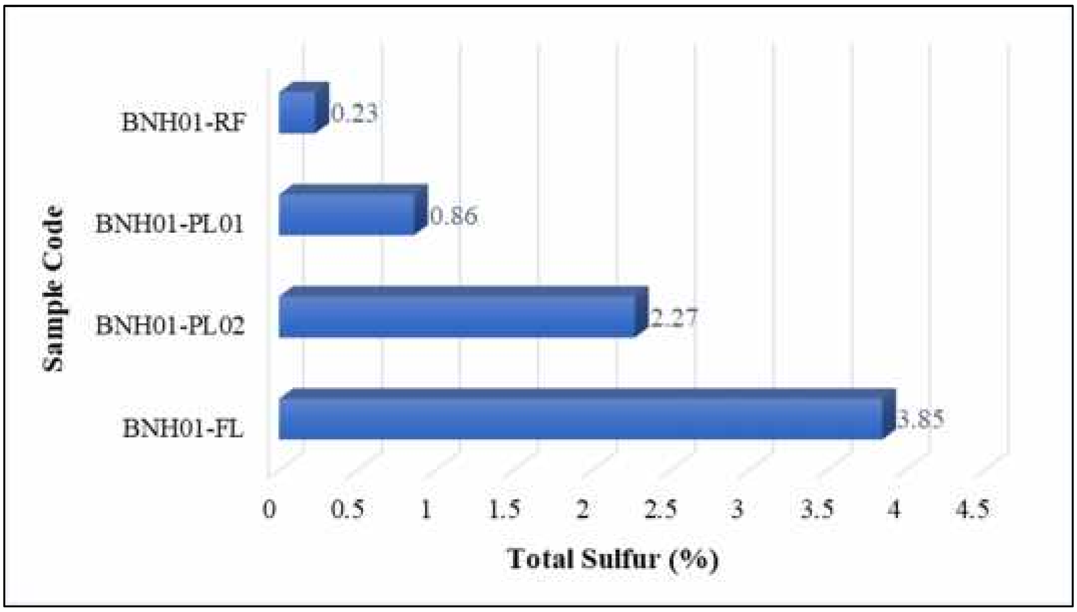


Figure 4. Total sulfur content of coal, overburden (roof), and underburden (floor) for station A.

*D. Results of total sulfur analysis in coal, overburden (roof) and underburden (floor) Station B*

The results of total sulfur analysis are shown in Table 2, and show the percentage of total sulfur BNH02-RF is 0.20%, BH02-PL01 is 1.30%, BNH02-PL02 is 4.45%, and BNH02-FL of 5.80%. Similar to the results of the total sulfur analysis for station A, the result of station B shows the total sulfur tend to be increasing from the roof to the floor as shown in Figure 5. Samples for station B demonstrate that the total sulfur distribution in vertical profile from the bottom (floor) to the top (roof) tend to be lower. It can be estimated that of sulfur content in the coal derived from underburden (floor) during coal formation.

## 4. Conclusion

Total sulfur content at the study area (station A and B) are categorized in four types, namely low, moderate, high, and super high sulfur (SHS). The sample shows top ply of coal has a low to moderate total sulfur, which is in the range of 0.86% to 1.30%, while the bottom ply of coal has a moderate to super high total sulfur, which is the value around 2.27% to 4.45%. The overburden (roof) has low total sulfur that is in the range of 0.20% to 0.23%, while the underburden (floor) has high to super high total sulfur which the value

Table 2. Results of total sulfur analysis of coal, overburden (roof), and underburden (floor) for station B

| No | Sample Code | Total Sulfur (%) |
|---|---|---|
| 1 | BNH02-RF | 0.20 |
| 2 | BNH02-PL01 | 1.30 |
| 3 | BNH02-PL02 | 4.45 |
| 4 | BNH02-FL | 5.80 |

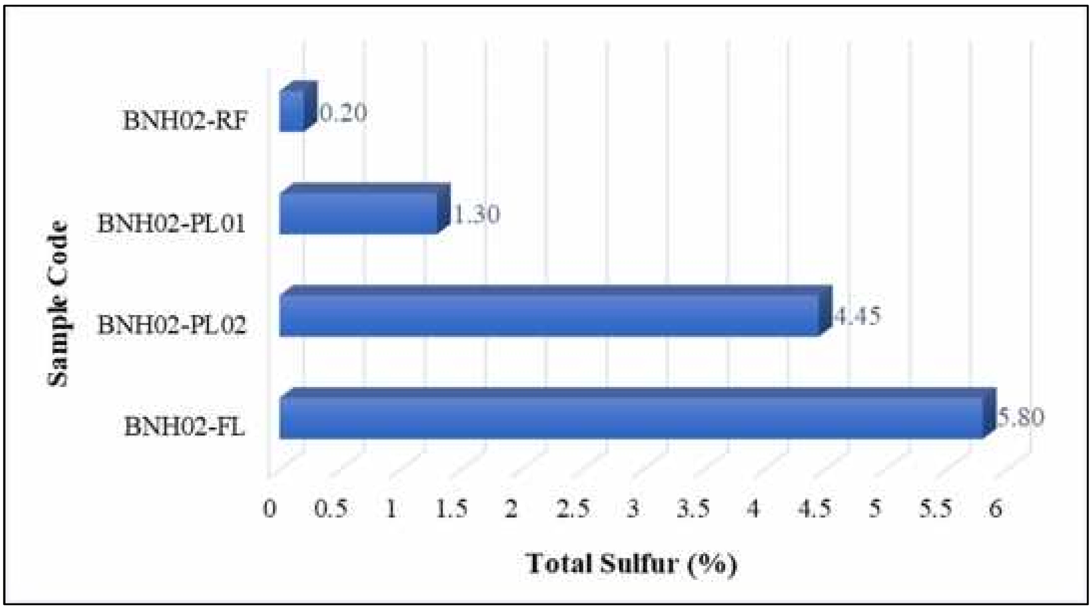


Figure 5. Total sulfur content of coal, overburden (roof), and underburden (floor) station B.

range from 3.85% to 5.80%. It can be concluded that the high total sulfur content in the coal seam originated from the underburden (floor) during coal formation.

**Acknowledgments:** This study is a scientific work as a part of the requirements of Mining Engineering Master Program. The authors would like to thank to the Mining Engineering Department as well as Mineral Analysis and Processing Laboratory Hasanuddin University for all supporting facilities provided during our study. The authors also wish to thank Mr. Perdianus Matarru's for his support during our coal sampling in the field, and PT. Sucofindo Makassar for coal samples analyses. We would like also to express our gratitude to editor and anonymous reviewers for their help, reviews, and comments for our manuscript.

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