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# Inorganic Geochemistry of Coal from Patappa Village, Bone District, and Masenrengpulu Village, Barru District, South Sulawesi Province Using XRF Method

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**Abstract**

The chemical composition of coal is almost the same as that of plant tissue, containing the main elements of elements C, H, O, N, S, and P. An in-depth study of coal inorganic compounds is needed because coal inorganic compounds are the primary variable in ash formation during coal combustion. This study uses the X-ray fluorescence method to reveal the differences and similarities in inorganic chemical composition contained in coal in Bone Regency and Barru Regency. Coal in Masenrengpulu Village has the $Al_2O_3$ compound as the most dominant compound, while coal in Patappa Village has the $SiO_2$ compound as the most prevalent compound. The concentration of inorganic sulfide minerals in the village of Masenrengpulu was influenced by igneous rock intrusion and deposition processes. In contrast, the deposition process only affected the inorganic sulfide minerals of coal in Patappa village. The significant elements found in coal in the Masenrengpulu and Patappa Villages are Si, Al, Fe, S, Ca, K, and Ti. Coal inorganic sulfide minerals in Masenrengpulu Village with Patappa Village have high concentrations in the bottom channel of the coal seam and a low concentration in the middle channel and top of the seam. Coal inorganic sulfide minerals in Masenrengpulu Village and Patappa Village have high concentrations in the coal seam's lower channel and low concentrations in the middle and upper channels.

**Keywords**: Coal Comparison, Mallawa Formation, XRF, Inorganic Geochemistry.

## 1 Introduction

Coal has been one of the most important fossil fuels for centuries [1,2]. The consumption of coal resources accounts for more than 32% of the total consumption of fossil fuels in 2021, and coal is the most abundant distributed fossil fuel in the world [3,4].



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The depositional environment is a characteristic of a geomorphic setting where physical, chemical, and biological processes produce a specific type of sediment [5,6]. The chemical composition of coal is almost the same as the chemical composition of plant tissue; both contain the main elements of C, H, O, N, S, and P [7,8]. An in-depth study of coal inorganic compounds is needed because coal inorganic compounds are the primary variable in ash (dust) formation during coal combustion [9,10].

Research on Mallawa Formation coal has been carried out regarding the study of coal depositional facies based on maceral composition in Barru Regency, South Sulawesi [11,12]. Improving the quality of sub-bituminous coal to bituminous coal by Brotowati and Sofia 2018 [13]. Analysis of the resistivity of Barru coal, Palluda Hamlet, Barru Regency, South Sulawesi Province by Umar, 2017 [14] Coal quality analysis based on proximate and ultimate test result in Masenreng Pulu Village, Lamuru District, Bone Regency by Bakri, 2022 [15].

Coal deposits in the Mallawa Formation are inserts in the middle Eocene age's shale, clay, and sandstone sequences. Mallawa Formation coal is thought to be associated with depositional environments near the coast or lagoons that influence the rise and fall of seawater [16]. The relatively high sulfur content reflects that the Mallawa Formation occurred in brackish water conditions [17]. Widodo et al., 2022 carried out in-depth research on the inorganic geochemistry of Mallawa Formation coal using X-ray diffraction, which revealed the characteristics of the pyrite mineral in coal based on the results of microscope, proximate, all sulfur and X-ray diffraction analysis to determine the potential for air formation mine acid [18].

To find out in-depth about the inorganic geochemistry of Mallawa Formation coal, conducting an in-depth study of the mineral elements contained in Mallawa Formation coal is necessary. X-ray fluorescence analysis of coal inorganic geochemistry can illustrate the comparison and synchronization of mineral elements contained in Mallawa Formation coal in the Bone Regency and Barru Babupaten areas, South Sulawesi Province.

# 2 Methods

**Initial Stages of Research**

The research will be conducted in Maenreng Pulu Village, Lamuru District, Bone District, Patappa Village, Pujananting District, and Barru District, South Sulawesi Province.

a. The administrative stage begins with preparing a research permit to obtain permission from the local area so that data legality and personal safety are better maintained when conducting research sampling. The research application letter issued by the industrial technology faculty is submitted to the investment office, then the investment office gives the research permit.
b. Literature study as a basic guideline for research activities and determination of steps that are sourced from references and also some information available at the research location that is appropriate to the subject matter.
c. Field orientation carried out overall observations regarding the location of the research area in Masenrengpulu Village, Lamuru District, Barru Regency, South Sulawesi Province.
d. Field observations carry out direct observations at activity locations in the research area.

**Data Retrieval Stages**

The data taken is in the form of primary data or data taken directly at the research location:

a. Collecting primary data at the research location in the form of coal position data, slope, coal flanking rock data, coordinate points, documentation, and coal samples [19].
b. Coal samples were taken using the channel sampling method by taking the upper and lower parts of the coal seam. Before taking samples using a sampling channel, the coal seam to be channeled is first cleaned of weathered coal to obtain coal that is still in fresh condition and so that it is protected from contamination of the flanking rocks. The coal taken is approximately 10 cm from the flanking rocks. After the coal seam has been made into a clean channel, the coal collection starts from the bottom channel

to make it easier to collect the coal and avoid contamination of the flanking rocks. Approximately 2 kg of coal is taken in each channel.

**Sample Preparation Stages**

The following stages of analysis of coal sample preparation are depicted in Fig. 1. The stages are:

a. The stage of reducing the size of the coal sample was carried out using a jaw crusher, then continued using a double roll crusher to obtain a maximum size before being put into the grinding tool [20], [21].
b. The grinding stage is the stage of reducing the size of the coal sample to obtain a coal sample with a length of -200 mesh. The tool used to grind coal to get a size of -200 mesh is a ball mill, and you can also use other grinding tools.
c. Sifting was carried out using a 200 mesh sieve to obtain a homogeneous size.
d. The stage for packaging the test sample is by packing it in a sample bag that has been labeled at ± 50 gr, and the backup sample is packed in a sample bag that has been marked at ± 300 gr.

**Sample Analysis Stages**

The following stages of the XRF analyst are shown in Fig. 2.

a. The ignition stage is the stage of converting coal samples measuring -200 mesh into ash samples. This is done because the tool XRF spectrometer cannot detect mineral elements in coal, which, in fact, dominantly has elements derived from organic

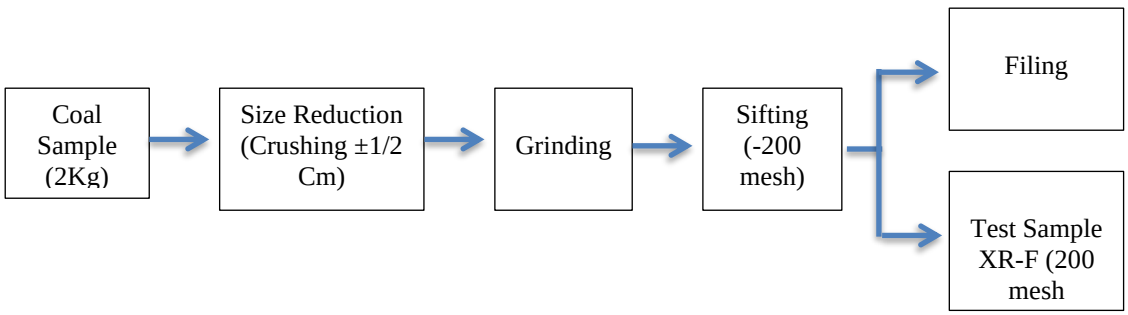



**Figure 1**. Flow of Sample Preparation Activities.

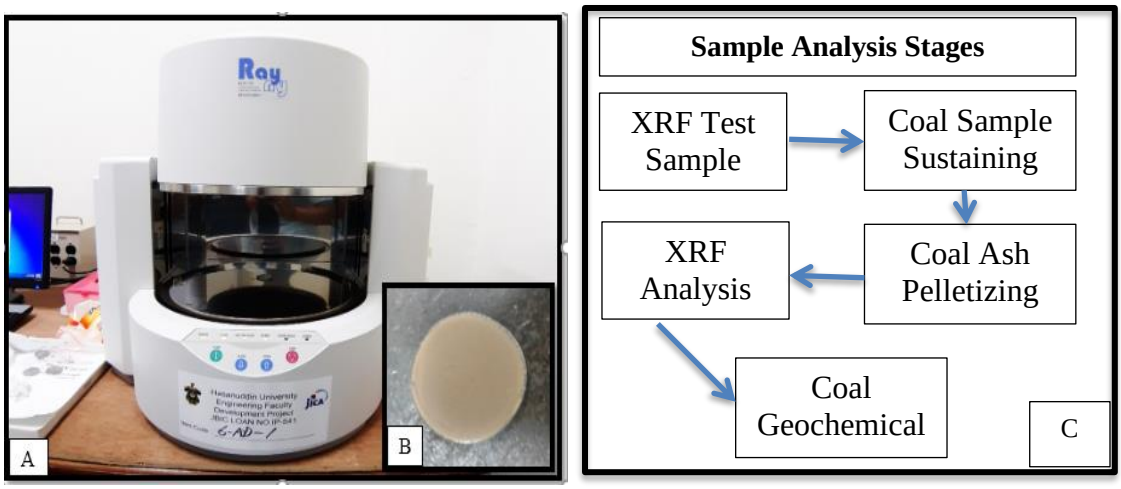



**Figure 2**. A. XRF spectrometer, B. Petete and C. Stages of Sample Analysis.

matter [10], [18], [22]. XRF analysis was conducted at the Laboratory of Hasanuddin University. The XRF tool brand is Shimadzu, EDX-720/800HS type.

b. Stages of converting ash samples into pellets. The finished pellet sample is inserted into the XRF Spectrometer tool for approximately 15 minutes.

**Data Processing Stages**

XRF analysis data processing is processed using Mc Excel to get an overview of the relationship between coal inorganic chemical composition for each coal channel and a comparison of the coal inorganic chemical composition of the Bone Regency area with the Barru Regency area [23-25].

**Stages of Report Preparation**

The preparation of the report begins with outlining the research, then proceeds with making an introduction including background using seven references, two of which are to describe the study in general as much as one paragraph and five references are used to provide information about previous researchers in the research area as much as two paragraphs as presented in Fig. 3. The background is closed with a novelte or overview of the feasibility of this research.

a. After the preparation of the Introduction is complete, it is continued with the preparation of research stages and methods to describe the flow of research activities from the beginning to the conclusion.
b. After the preparation of the stages and methods of research is complete, it is continued by compiling the data processing results into scientific reporting forms equipped with clear and systematic explanations.
c. After the preparation of the results and discussion is complete, it is continued with a closing that contains conclusions that synchronization of research objectives and suggestions for future researchers.
d. After the preparation of the cover is complete, continue by making a summary and abstract that explains the essence of the research, followed by the preparation of the authorization letter, preface, table of contents, list of figures, and table list.

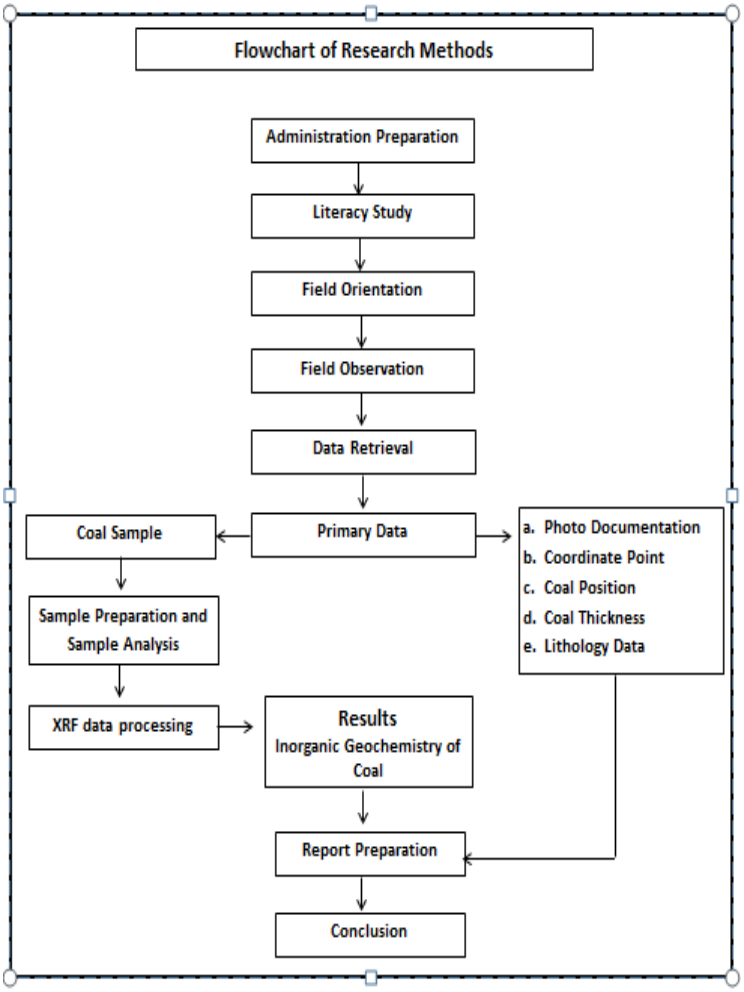



**Figure 3.** Flowchart of Research Methods.

# 3 Results and Discussions

**Lokasi Penelitian Batubara**

a. Bone Regency Coal

The coal at the research location is in Masenrengpulu Village, Lamuru Subdistrict, Bone Regency, South Sulawesi Province, with coordinates 119$^{o}$ 56' 26.8" N and 4$^{o}$ 41' 11.7" E (see Fig. 4). The coal at this location has a position of N 265oE/18o with a thickness of 165 cm and a slope of 60$^{o}$. The coal in this location has a position of N 265$^{o}$E/18$^{o}$ with a thickness of 165 cm and a slope of 60°. The roof rock in Masenrengpulu Village is silica sandstone, while the floor rock is andesite igneous rock in the form of sills.

b. Barru Regency Coal

Coal in the research location, Patappa Village, Pujananting Subdistrict, Barru Regency, South Sulawesi Province, has a position of N 275$^{o}$E/12$^{o}$ with a thickness of 110 cm and a slope of 65$^{o}$ (see Fig. 5) The roof rock in Patappa Village is passive mudstone, while the floor is mudstone.




**Figure 4.** Coal of Masenrengpulu Village, Bone Regency.




**Figure 5.** Coal of Patappa Village, Barru Regency.

## Coal Inorganic Geochemistry

a. Regional Coal of Bone Regency

The Table 1 illustrates the concentration of the chemical composition of coal minerals in Masenrengpulu Village, Lamuru Sub-district, Bone Regency, South Sulawesi Province. In general, coal at the research location has the most dominant concentration of $Al_2O_3$ compounds, followed by $SiO_2$, $Fe_2O_3$, $SO_3$, CaO, K2O, TiO, SrO, MnO, $V2O_5$, $Cr_2O_3$, NiO, CuO, $ZrO_2$, $Y_2O_3$, ZnO, and MoO3 (see Fig. 6).

**Table 1.** Comparison of Mineral Compounds in Bone Regency Coal

| No | Chemical Composition | Channel 1 | Channel 2 | Channel 3 | Rata-Rata |
|---|---|---|---|---|---|
| 1 | $SiO_2$ (MM) | 28.95% | 35.90% | 27.60% | 30.82% |
| 2 | $SiO_2$ (MS) | 33.10% | 60.02% | 61.50% | 51.54% |
| 3 | $Al_2O_3$ (MM) | 36.22% | 45.82% | 37.02% | 39.69% |
| 4 | $Al_2O_3$ (MS) | 26.05% | 30.64% | 32.60% | 29.76% |

| | | | | | |
|---|---|---|---|---|---|
| 5 | $Fe_2O_3$ (MM) | 25.47% | 12.28% | 29.73% | 22.49% |
| 6 | $Fe_2O_3$ (MS) | 22.70% | 5.03% | 3.21% | 10.31% |
| 7 | $SO_3$ (MM) | 5.84% | 2.59% | 2.59% | 3.67% |
| 8 | $SO_3$ (MS) | 9.78% | 1.44% | 0.47% | 3.90% |
| 9 | CaO (MM) | 1.88% | 1.63% | 1.41% | 1.64% |
| 10 | CaO (MS) | 6.78% | 0.91% | 0.56% | 2.75% |
| 11 | $K_2O$ (MM) | 0.78% | 0.93% | 0.88% | 0.86% |
| 12 | $K_2O$ (MS) | 0.63% | 1.14% | 0.97% | 0.92% |
| 13 | $TiO_2$ (MM) | 0.39% | 0.62% | 0.56% | 0.52% |
| 14 | $TiO_2$ (MS) | 0.58% | 0.71% | 0.63% | 0.64% |

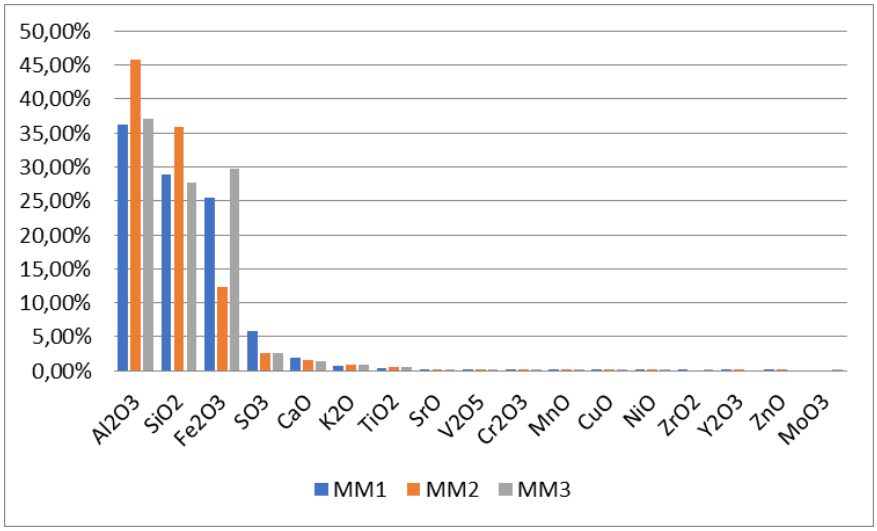



**Figure 6.** Comparison Chart of Bone Regency Coal Mineral Compounds.

b. Regional Coal of Barru Regency

The Table 2 illustrates the concentration of the chemical composition of coal minerals in Patappa Village, Pujananting Subdistrict, Barru Regency, South Sulawesi Province. In general, coal at the research location has the most dominant concentration of $SiO_2$ compounds, followed by $Al_2O_3$, $Fe_2O_3$, $SO_3$, CaO, K2O, TiO, SrO, MnO, $V2O_5$, $Cr_2O_3$, NiO, CuO, $ZrO_2$, $Y_2O_3$, ZnO, and MoO3 (see Fig. 7).

**Table 2** Comparison of Coal Mineral Compounds of Barru Regency.

| No | Komposisi Kimia | MS1 | MS2 | MS3 | Rata-Rata |
|---|---|---|---|---|---|
| 1 | $SiO_2$ | 33.10% | 60.02% | 61.50% | 51.54% |
| 2 | $Al_2O_3$ | 26.05% | 30.64% | 32.60% | 29.76% |
| 3 | $Fe_2O_3$ | 22.70% | 5.03% | 3.21% | 10.31% |
| 4 | $SO_3$ | 9.78% | 1.44% | 0.47% | 3.90% |
| 5 | CaO | 6.78% | 0.91% | 0.56% | 2.75% |
| 6 | $K_2O$ | 0.63% | 1.14% | 0.97% | 0.92% |
| 7 | $TiO_2$ | 0.58% | 0.71% | 0.63% | 0.64% |
| 8 | MnO | 0.12% | 0.02% | 0.00% | 0.04% |
| 9 | $As_2O_3$ | 0.06% | 0.00% | 0.00% | 0.02% |
| 10 | SrO | 0.06% | 0.02% | 0.00% | 0.03% |
| 11 | $Cr_2O_3$ | 0.05% | 0.00% | 0.00% | 0.02% |
| 12 | $ZrO_2$ | 0.02% | 0.04% | 0.04% | 0.04% |
| 13 | CuO | 0.02% | 0.00% | 0,00% | 0,01% |
| 14 | ZnO | 0.02% | 0.01% | 0.01% | 0.01% |
| 15 | $V_2O_5$ | 0.02% | 0.00% | 0.00% | 0.00% |
| 16 | $Y_2O_3$ | 0.01% | 0.00% | 0.00% | 0.00% |
| 17 | $MoO_3$ | 0.01% | 0.00% | 0.00% | 0.00% |
| 18 | $Ag_2O$ | 0.00% | 0.02% | 0.00% | 0.01% |
| 19 | $SrO_2$ | 0.00% | 0.00% | 0.01% | 0.00% |

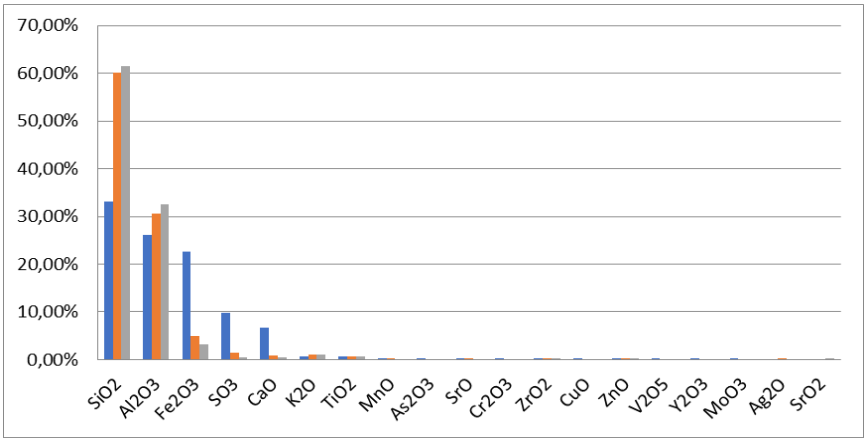



**Figure 7.** Comparison Chart of Coal Mineral Compounds of Barru Regency.

## Coal Inorganic Chemical Composition Comparison

Figs. 8-11 illustrates the comparison of the concentration of the chemical composition of coal minerals in Masenrengpulu Village, Lamuru Subdistrict, Bone Regency, and Patappa Village, Pujananting Subdistrict, Barru Regency, South Sulawesi Province.

Coal in Patappa Village has a higher concentration of $SiO_2$ compounds, while coal in Masenrengpulu Village has a higher concentration of $Al_2O_3$ compounds. Coal in Patappa Village has a $SiO_2$ compound concentration of 51.54%, while coal in Masenrengpulu Village has a $SiO_2$ concentration of 30,816%. Coal in Patappa Village has a concentration of $Al_2O_3$ compounds of 29.761%, while coal in Masenrengpulu Village has a $SiO_2$ concentration of 39.688%.

Coal in Masenrengpulu Village has a higher concentration of $Fe_2O_3$ compounds than coal in Patappa Village. Coal in Masenrengpulu Village has a Fe2O3 compound concentration of 22.491%, while coal in Patappa Village has a $Fe_2O_3$ concentration of 10.31%. Coal in Masenrengpulu Village has similarities in deposition patterns from the beginning to the middle of the deposition process. The deposition pattern changes from the middle to the end of the deposition. From the beginning of deposition until the middle of the coal deposition process, $Fe_2O_3$ compounds together decreased. Still, in the middle to the end of the deposition, $Fe_2O_3$ coal compounds in Masenrengpulu Village increased while $Fe_2O_3$ coal in Patappa Village was relatively stable.

The pattern of deposition of $SO_3$ compounds in Masenreng Pula Village and Patappa Village is relatively similar. Where at the beginning to the middle of the $SO_3$ compound deposition process decreases, then in the middle to the end of the deposition process, the SO3 compound is relatively stable. The deposition of CaO compounds in coal in Masenrengpulu Village is challenging from the beginning to the end of the deposition process. The deposition of CaO compounds in Patappa Village coal has decreased from the beginning to the middle of the deposition process. In contrast, in the middle to the end of the deposition process the CaO compounds are relatively stable. The deposition of $K_2O$ compounds in Masenrengpulu Village and Patappa Village is relatively stable from the beginning to the end of the deposition process. The deposition of $Ti_2O$ compounds in Masenrengpulu Village and Patappa Village from the beginning to the end of the deposition process is relatively stable.

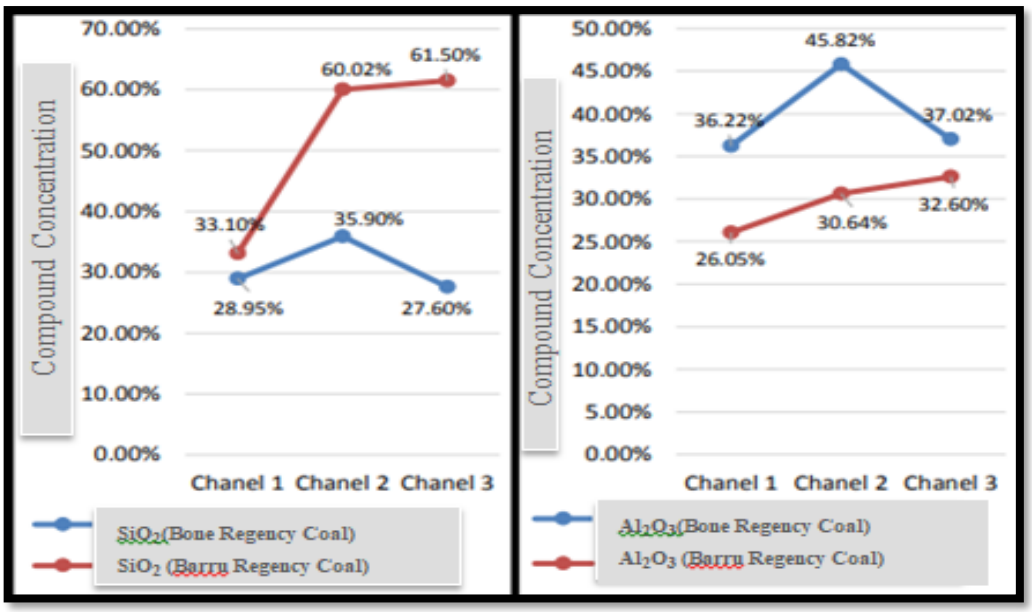



**Figure 8.** Comparison Chart of $SiO_2$ Compounds in Bone Regency and Barru Regency on the Left and $Al_2O_3$ compounds in Patappa Village and Masenrengpulu Village on the Right.

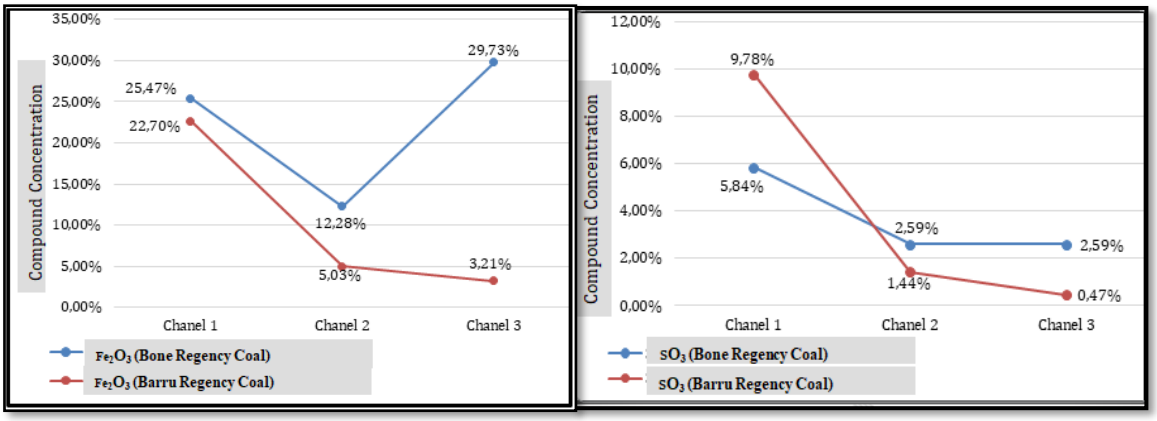



**Figure 9.** Comparison Chart of $Fe_2O_3$ and $SO_3$ Compounds in Coal in Bone Regency and Barru Regency.

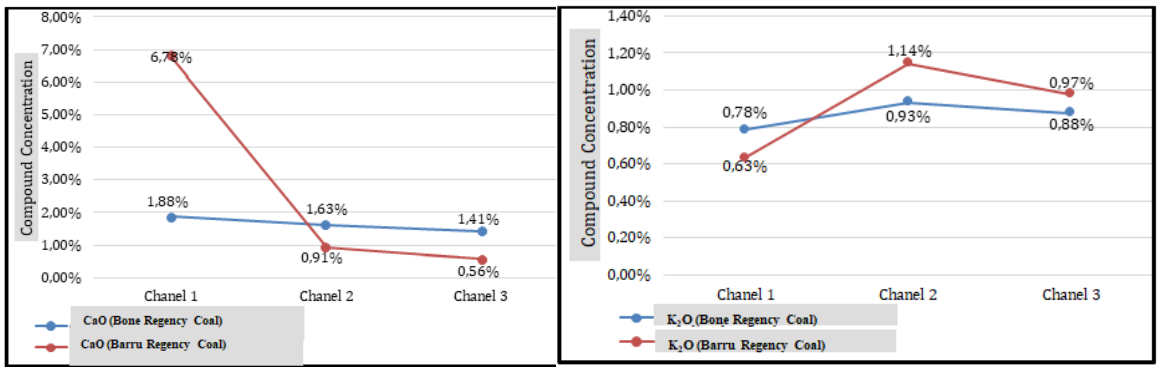



**Figure 10.** Comparison Chart of CaO and $K_2O$ Compounds in Coal in Bone Regency and Barru Regency.

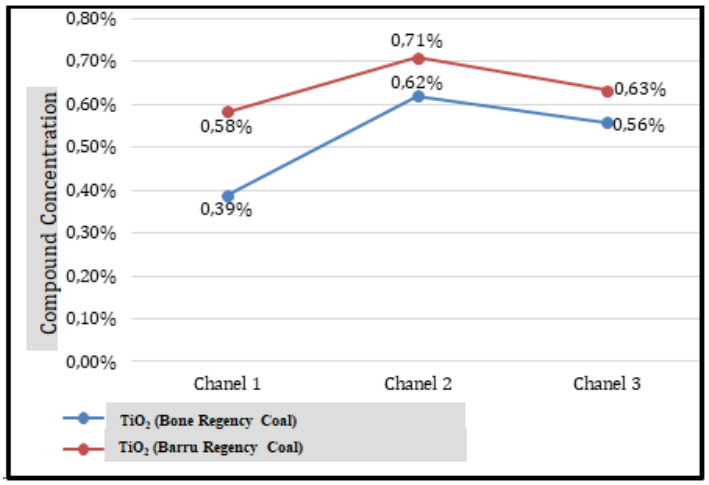



**Figure 11.** Comparison Chart of $TiO_2$ Compounds in Coal in Bone Regency and Barru Regency.

# 4 Conclusions

The difference in the inorganic geochemical composition of coal in Masenrengpulu Village and Patappa Village is in the $Al_2O_3$ and $SiO_2$ compounds. Coal in Masenrengpulu Village has $Al_2O_3$ as the inorganic compound with the highest concentration, while coal in Patappa Village has $SiO_2$ as the inorganic compound with the highest concentration. The concentration of coal inorganic sulfide minerals in Masenrengpulu Village is influenced by igneous intrusion and precipitation processes. In contrast, the precipitation process only affects coal inorganic sulfide minerals in Patappa Village. The similarity of the inorganic geochemical composition of coal in

Masenrengpulu Village with Patappa Village is that both have significant elements of Si, Al, Fe, S, Ca, K, and Ti. Coal inorganic sulfide minerals in Masenrengpulu Village and Patappa Village have high concentrations in the coal seam's lower channel and low concentrations in the middle and upper channels.

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