ADDIS ABABA INSTITUTE OF TECHNOLOGY

CENTER FOR ETHIO-MINES DEVELOPMENT

MASTER OF DEGREE IN MINERAL ENGINEERING

A MASTERS PROJECT ON

CHARACTERIZATION OF COAL COMPOSITION OF SHELA AREA, WOLAYITA ZONE, SOUTHERN ETHIOPIA, IMPLICATION FOR COAL QUALITY INDICATION

BY

ABINET MARKOS KELBISO

ADDIS ABABA UNIVERSITY, ADDIS ABABA, ETHIOPIA

JUNE, 2023

Approval sheet

Characterization of coal composition of shela area, wolayita zone, southern ethiopia, implication for coal quality indication. Submitted in the partial fulfilment of the requirement for the degree of master of engineering in mineral process compiles with the regulations of the university and meets the accepted standards with respect to originality and quality.

Approved by Advisor and Examiner

Name	Signature	Date
Examiner: Dr. Melese Alemayehu	----------------------------	-----------------------
Advisor: Dr. Sofiya Abdulkadir	----------------------------	------------------------
Director of Centre for Ethio-Mines Development		
Dr. Eng.Birhanu Assefa	---------------------------	------------------------

ADDIS ABABA UNIVERSITY, ADDIS ABABA, ETHIOPIA

JUNE, 2023

Declaration

I hereby declare that the project entitled ‘‘characterization of coal composition of Shela area, Wolayita Zone, Southern Ethiopia, Implication for coal quality Indication’’ was prepared by me, with the guidance of my advisor Dr. Sofiya Abdulkadir. The work contained herein is my own except where explicitly stated otherwise in the text, and that this work has not been submitted, in whole or in part, for any other degree or professional qualification.

Abinet Markos (MSc. Candidate)

Signature.______________. Date._____________.

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ACRONYMS AND ABBREVIATIONS

AC………………………………..	Ash content
ASTM……………………………	American societies of testing material
BTU………………………………	British Thermal units
CV………………………………..	Calorific value
D.m.m.f…………………………..	Dry mineral matter free
Lb…………………………………	pound
VM……………………………….	Volatile mater
MC……………………………….	Moisture content
M.m.m……………………………	Moist Mineral matter free
FC…………………………………	Fixed carbon
Kcal……………………………….	kilo calorie

ABSTRACT

The present study focused on the mineral characterization of Kindo-Didaye coal by adiabatic Calorie Metter, Gravimetric, hard groove index and proximate techniques. The result showed that coal quality ranged between (2475.79-10931.96Btu/lb); Sulphur (<0.02 % to 2.93%), moisture (1.21 to 1.99 %), volatile matter (15.45 to 26.37%), ash content (28.19 to 71.26%) and fixed carbon (11.21 to 44.23%). The majority of the Coal samples fall within lignite “B”, sub-bituminous “B” and sub-bituminous “C” ranks and none agglomerating. The grindablity index of the majority of the coal samples has the range (56.2-66), which HGI values of the Shela area coal samples indicate that most of the samples can be characterized as lignite and are also extremely challenging to grind.

Keywords: Proximate analysis, Calorific value, Rank, Sulphur content, Coal quality

CHAPTER ONE

INTRODUCTION

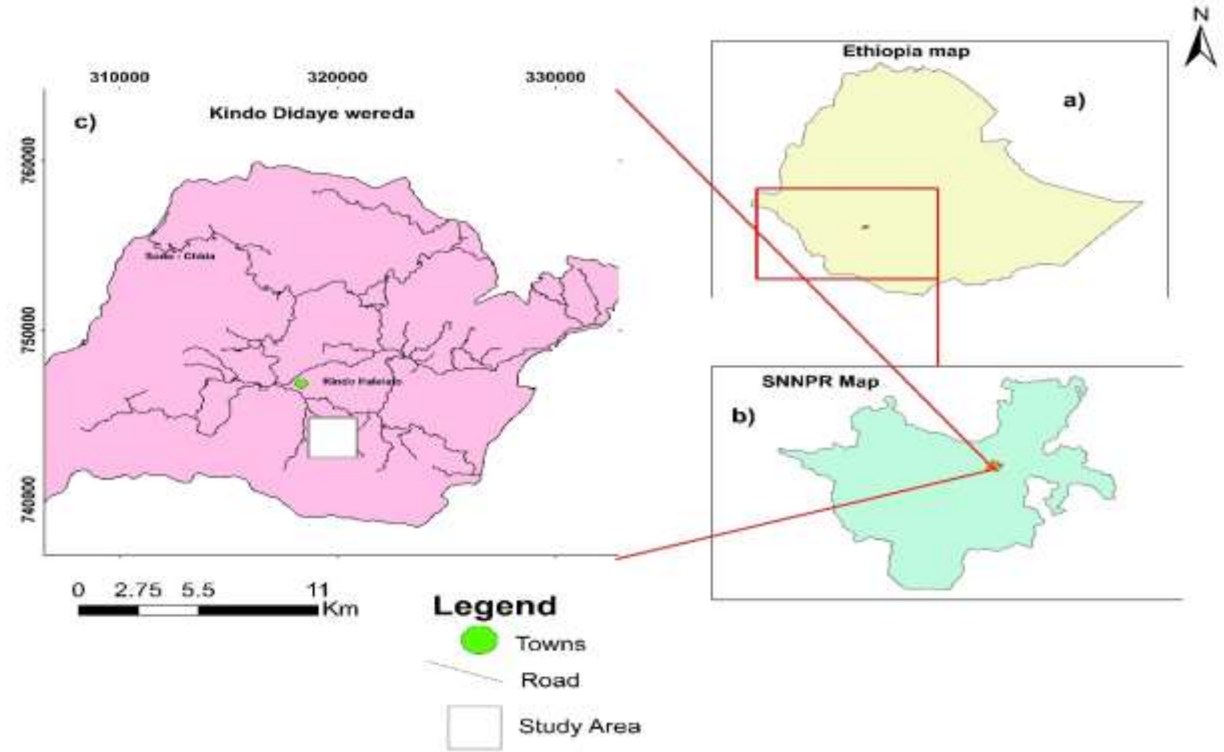
Coal is an international industry that significantly boosts the world economy. More than 50 countries engage in commercial coal mining, and more than 70 use coal. The production of electricity accounts for about 75% of the approximately 5,800 million tons of coal consumed annually worldwide. A mixture of both organic and inorganic "combustible" materials, coal is a heterogeneous "combustible" material.

According to Omar (1994), Ethiopia is the bottom per-capital strength usage of natural strength and spends a massive proportion of its general overseas income on imported fuels. Ethiopia's strength useful resource circumstance has big strength sources consisting in particular of biomass, hydropower, geothermal and fossil fuels. Moreover, maximum of the primary financial sectors are depending on imported petroleum or oil merchandise, at the same time as the expenses of those merchandise. Therefore, we've got visible exceptional opportunity supply of electricity as opposed to the biomass gas electricity for home electricity reassets. One of the opportunity supply of electricity is coal, however, earlier than the use of the coal for optimization of processing plant, beneficiation, flotation and dense media separation. Previous feasibility, study and exploration work activities were focused mainly on the quantity and occurrence of coal in the place. However, this study intended at detail coal composition, rank and quality of coal seam deposit in the Shela area based on integrated from outcrop data. The Shela area coal deposit is lacks detail coal composition with other coal deposits in the basin and calorific value and sulphur analysis which will enables us to understand the coal quality. The Shela area coal deposit sites were no detail composition characterization relatively with other coal deposits in the Ethiopian basin. And however, it will be analysed detail, it should be enables us to understand more the quality of the coal. And also it would be used as inputs for the optimization of processing plants.

Therefore, in order to constrain the power capacity of coal in the region, there is a need for detail proximity, calorific value and sulphur analyses investigations.

1.1, location map of the study area.

The area of particular interest for the current investigation was located along a dirt road 72 kilometers from Wolayita Sodo city to Shela Mekira Kebele. Shela Mekira area served as the study's chosen portion, and was discovered in the Southern region where the exposed coal resources were. Five outcropped pieces were chosen from the study area. The accompanying figure (1.1) depicts the study area's accessibility and location.



A location map of the study area is shown in Figure 1.1, along with the borders of Ethiopia, the South Nation Nationality People Regional State, and the Kindo-Didaye woreda.

1.2. OBJECTIVES

1. 2. 1. General Objectives

- The main objective of this project was characterization of coal composition, implication for coal quality indication.

1.2.2. Specific objectives

- Coal's proximate analysis.
- To calculate the calorific value, which measures heat energy
- To use American Society for Testing and Materials Standards for Coal Analyses (ASTM) to categorize the types of coal found in the study area.

CHAPTER TWO

LITERATURE REVIEW

2. Formation of Coal

Coal is a flammable solid substance (sediment, organic rock) that is created when deceased plant matter decomposes into peat and is transformed into coal by the warmth and pressure of deep burial over millions of years. Although the primary element of coal is carbon (70%), there are other constituents like oxygen, hydrogen, sulphur, and other contaminants which make up 30% together. The primary factors used to define the mineralogy of coal are the heating value (HV), ash content, moisture, and sulphur (www.worldcoal.org).

2.2 Geographic setting

The study area is covered with varieties of lithological units as it is mentioned in the geological map in the (figure 1). Both sedimentary and igneous rocks are found in the study area. The most dominant lithological units in the study area are rhyolite, basalt and coal. Besides to the above mentioned rock units, non-mappable rock units like dolerite outcrops are apparently observed in the study area. The sedimentary units exposed in the study area are shale and coal beds.

Basalt is the most dominant rock unit found in the study area. It has aphanitic texture with dark colour due to its mafic composition. The basalt unit makes a contact with both rhyolite and coal beds. Mineralogical of this unit phenocrysts of plagioclase and olivine on the ground mass of fine-grained plagioclase, pyroxene minerals. Adjacent to the river bed tilted columnar joints are found in contact with trachyte lithology.

2. 1. Field photo taken from this section is located exposed by the stream cut

Samples of coals from outcrop of the study area shows that the coal has plant remains on its surface and this tells us that the coals genetic type refers for humic nature and oil shale exposed at this area is less fissility and visible. It is 0.1m thick. It consists of the parallel lamination, cleats and joints with some plant fossils.

Figure 2.2. Photo taken from Volcanic Clastic Sediments

The upper basalt is closely related to this deposit, which is found in the fluvio-lacustrine strata. The upper basalts that have weathered make up the majority of it. In this studied area, the lateral extension of this volcanic clastic is infrequently seen. This sediment is the top-ranking reworked Tuffaceous (volcanic clastic) sediment; it is in the field observed to vary in color from location to location. This sediment is primarily made up of reworked volcanoclastic mudstones in the sizes of clay, silt, and sand. Different-thickness coal seams were discovered in this study area's sedimentary rocks with gentle slope. The coal seams are nearly horizontal and shallow. They have been impacted by a number of igneous intrusions, the intrusions generated by the uplift of the mountains falling under the category of lignite coal. The study area's north and east have a number of basins where the coal fields are situated. The Gibeomo river system contains carbonaceous pre-Oligocene sediments that are coal-bearing. The coal seams in this formation were sculpted by the alluvial river and delta system that surrounded them. The coal has a maximum thickness of 3 meters, a medium ash content, and a medium rank.

CHAPTER THREE

METHODOLOGY

To attain the goal of this undertaking, distinct techniques had been followed:

3. during Fieldwork

For this study, representative samples were taken separately, total five numbers of outcrop coal samples were collected by trench and pitch from Shela area, exploited randomly with some distance interval and about 1.5 kg of coal samples were collected for each. Why? Because randomly, each coal sample has an equal probability of being chosen and is meant to be an unbiased representation of group. the observed exposures of the Coal seams and field mapping involving carful sampling of study area was undertaken at the field and representative Coal samples were collected was tightly wrapped with masking tape in a plastic bag for the sake of preservation for laboratory analyses such as proximate, sulphur, and calorific value by following the International and national standards coal analyses guidelines i.e. American Society for Testing and Materials standards for coal analyses https://www.tsamfg.com/specifications/astm/The selected samples were analysed at a Central Geological Survey laboratory of Ethiopia in May 2023.

3.1. Determination of the coal composition by proximate analysis

3.1.1. Moisture content analysis:

A known quantity of coal was heated to 105-110oc in an electric hot air oven for roughly one hour to assess the moisture content of the air dried coal. It was removed from the oven after an hour, allowed to cool in a desiccator, and then weighed.

3.1.2. Volatile material analysis:

Consists of complicated combination of gaseous and liquid merchandise of because of the thermal decomposition of the coal. It is decided via way of means of heating an acknowledged weight of moisture loose coal pattern in an included platinum crucible 950±20ºc for 7 minutes3.

3.1.3. Ash analysis:

Coal contents inorganic mineral substance that are transformed in to ash via way of means of chemical reactions throughout the combustion of coal. Ash normally includes silica, alumina, iron oxide and small portions of lime and magnesium. It is decided via way of means of heating the residue left after elimination of risky cloth at 700±50ºc for ½ an hour without covering.

3.1.4. Fixed Carbone analysis:

Fixed carbon content material cloth will boom from lignite to anthracite. Higher the percentage of consistent carbon extra is calorific value and better is high-quality of coal.

3.2. Calorific value analysis

The calorific value or heat of combustion or heating value of a sample fuel is defined as the amount of heat evolved when a unit weight (or volume in the case of a sample of gaseous fuels) of the fuel is completely burnt and the products of combustion cooled to a standard temperature of 298ºK. The calorific value of coal was calculated by using the following relation:

3.3. Determination of Sulphur:

A regarded amount of coal became heated with Eschka mixture (which includes 2 elements of MgO and 1 a part of anhydrous Na2CO3) at 800˚C.After burning quantity of sulphur gift within side the blend became retained as oxides and it became triggered as sulphates. The sulphate fashioned became triggered as BaSO4 (via way of means of treating with BaCl2).

3. 4. Overall structure of Experimental design is shown

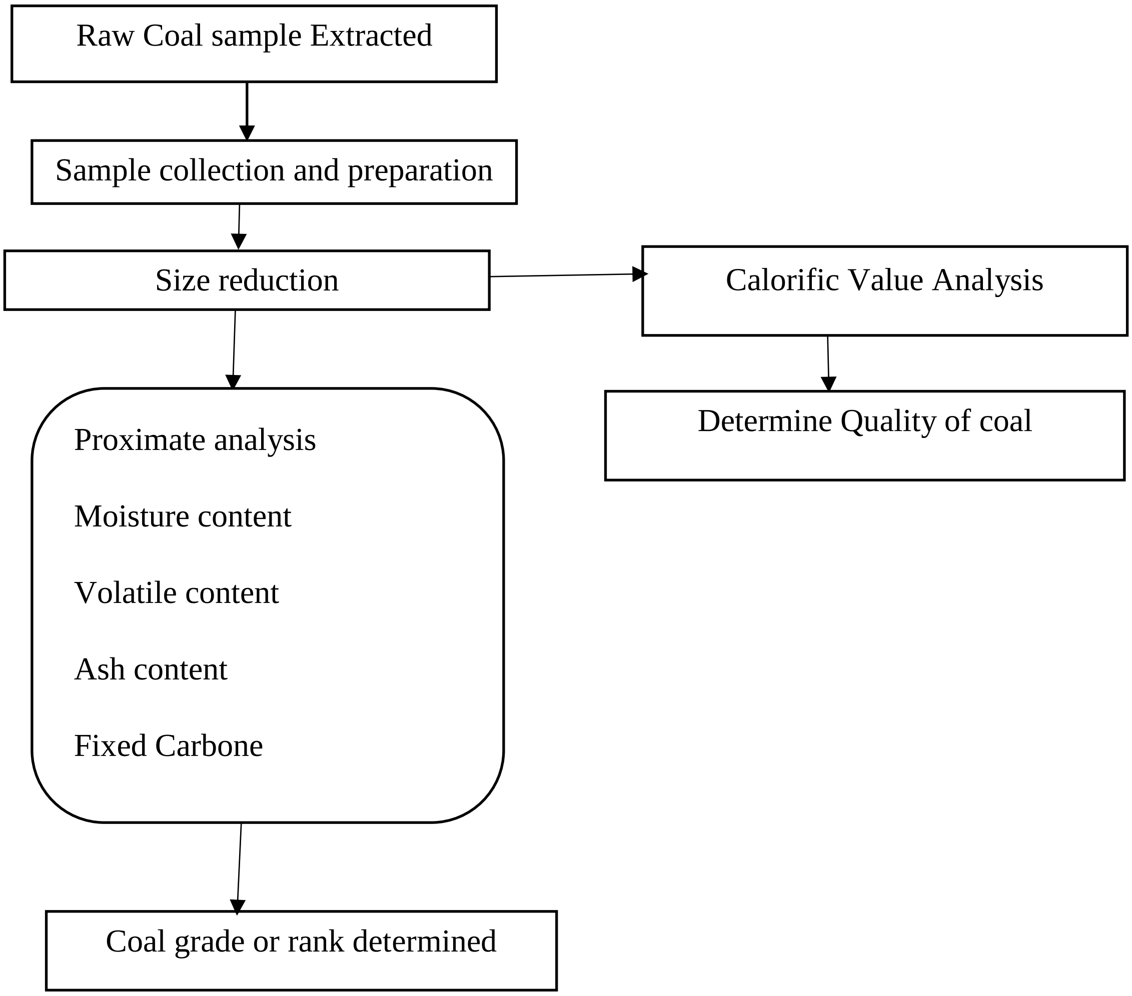


Figure 3.1. Experimental design of the project work.

CHAPTER FOUR

RESULT AND DISCUSSION

4. PROXIMATE EXAMINATION

During proximate evaluation, the risky matter, inherent moisture content, ash content, and amount of constant carbon within side the coal have been decided the use of the identified ASTM method. These effects are giant parameters for comparing the fine of the coal. The proximate evaluation effects are supplied in desk and graph format, offering records approximately the purity and requirements of the coal. The maximum giant parameter indicating coal fine is the calorific value. The effects of every pattern evaluation may be located on the following page.

4.1. Determination of moisture content

The recorded moisture content outcomes are shown in table 4.1, the moisture content of the coal ranges from 1.21% to 1.99%, with an overall average of 1.6%. Samples S1 and S3 have higher moisture content compared to samples S2 and S4.

Table4.1. Amount of moisture content obtained from experimental result

Sample No	Moisture content in %
S1	1.99
S2	1.21
S3	1.99
S4	1.32
S5	1.83

S1=Sample1, S=Sample2, S3=Sample3, S4=Sample4, S5=Sample5.

4.2. Determination of volatile mater

The result that were obtained from experimental values of table 4.2. The result indicates that the coal sample has volatile matter content percent in the range of 15.45 - 26.37 %.

Table .4.2. Amount of volatile matter of shela area obtained from experimental result.

Sample Number	Volatile matter (%)
S1	15.45
S2	26.37
S3	15.54
S4	24.52
S5	19.07

4.3. Determination of ash content

The laboratory recorded ash content results are described below in table 4.3.

Table 4.3. Ash percent content experimental result of coal

Sample No	Ash content (%)
S1	71.17
S2	28.19
S3	71.26
S4	35.75
S5	61.26

The proximate analysis results for all the coal samples are presented in the following table:

Table 4.4. Composition result of the coal sample (%)

Sample No	Moisture (%)	V.M (%)	Ash (%)	Fixed Carbone (%)
S1	1.99	15.45	71.17	11.38
S2	1.21	26.37	28.19	44.23
S3	1.99	15.54	71.26	11.21
S4	1.32	24.52	35.75	38.41
S5	1.83	19.07	61.26	17.84

4.4. Determination of calorific value analysis

. The calorific value of the coal are shown in the table 4.5 below,

Table 4.5. Calorific value of Shela coal

Sample No.	Calorific value(cal/gm)	Calorific value(Btu/lb)	Calorific value(kcal/kg)
S1	1347.66	2425.788	1347.66
S2	5445.18	9801.324	5445.18
S3	1326.68	2388.024	1326.68
S4	4995.83	8992.494	4995.83
S5	2586.83	4656.294	2586.83

S1=Sample1, S2=Sample2, S3=Sample3, S4=Sample4, S5=Sample5.

4. 5. Determination of sulphur content

For assessing coal quality, sulphur is the main element because a high amount of sulphur is a risk for technological applications and environmental impact. So sulphur is the crucial relevant factor in assessing the coal quality. The coal collected from the southwestern of the study area from outcrop sample very low < 0.02% (S1 and S3) ranges to high the outcrop sample 2.93(S2).

Table .4.6. The experimental result of sulphur content

Sample No.	Sulphur content (%)
S1	<0.02
S2	2.93
S3	<0.02
S4	0.89
S5	0.03

According to Chou (2012) based on the percentage of sulphur content coals have been classified into three types namely; low sulphur (< 1% sulphur contents) (S1, S3, S4 and S5), medium sulphur (> 1% to < 3% sulphur content) (S2), and high sulphur coals (> 3% sulphur content) depend on the sample analysed, Four samples are belongs to low and one sample is medium sulphur contents. From the analysed samples, no samples were categorized under high sulphur contents, and then the

Shela coal were categorized belongs to low and medium sulphur contents. The S1, S3, S4 and S5coal samples are fairly low sulphur Coals used extensively as gas coal and also as smithing and steam coal. Generally, the sulphur contents of the study area are very low to moderate in the percentage used for industrial applications.

4.6. Determination of coal grade

In accordance with the ASTM (American Society for Testing and Materials) classifications, (D388-1999) is universally used. This classification is based on two properties of coal, the fixed carbon values (on a dry mineral matter-free basis) and the calorific values (on a mineral matter-free basis). According to ASTM (D388-1999), if the gross calorific value (Btu/lb) falls between 8,300 and 9,500 Btu/lb, it is classified as sub-bituminous "C"; if it falls between 6,300 and 8,300 Btu/lb, it is classified as lignite "A"; and if it falls below 6,300 Btu/lb, it is classified as lignite "B". The coal in the study area is classified as S1 (2425.79 Btu/lb), S3 (2388.024 Btu/lb), and S5 (4656.294 Btu/lb), which are lower rank coals based on their calorific values (Table 6.5). Sample No. S2, on the other hand, has a higher calorific value of 9801.324 Btu/lb, and according to this scheme, the rank of coal in certain sections of the study area ranges from the lowest energy value (4656.294, 2388.024, 2425.79 Btu/lb) to the highest energy value (9801.324 Btu/lb). The outcrop samples from sample No. S1, S3, and S5 are categorized as lignite "B", respectively. Sample No. S4 is classified as sub-bituminous "C", which is a medium rank coal with medium energy value, while sample No. S2 is categorized as high-volatile bituminous "B", which is a higher rank coal with higher energy value.

Table. 4. 4. Rank classification based on ASTM (D388-1999)

Sample No.	Calorific value(Btu/lb,(m.m.m.f.b)	Rank	Agglomerating character
S1	2425.788	Lignite ‘‘B’’	no agglomerating
S2	9801.324	Sub-bituminous ‘‘B’’	no agglomerating
S3	2388.024	Lignite ‘‘B’’	no agglomerating
S4	8992.494	sub-bituminous ‘‘C’’	no agglomerating
S5	4656.294	Lignite ‘‘B’’	no agglomerating

Generally, the laboratory end result analysed samples within side the look at location shows the coals have low to medium moisture content, risky matter, and ash content, and occasional sulphur with few samples are medium sulphur, especially low constant carbon content. The majority of the coal samples fall inside lignite “B”, sub-bituminous “B” and sub bituminous “C” ranks and none agglomerating. Comparatively, the calorific price of Coal Btu/lb from, S2 and S4 are extra than that of S1, S3 and S5. The Coal with the best calorific price is the pleasant and cleanest sort of coal to use. Generally, the mission look at location, coal pattern No.S2 and S4 are better ranks from the look at location categorised beneath sub-bituminous ‘’C’’ and sub-bituminous ‘’B’’. The studied coal pattern categorize lignite B, sub-bituminous ‘’B’’, and subbituminous C.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1. CONCLUSION

The proximate analysis, calorific value analysis, sulfur content and hard grove grindablity analysis of the coal reveal extraordinary characteristics.

The laboratory proximate analysed consequences indicated that the moisture, volatile matter, ash contents, and fixed carbon value range from 1.21 to 1.99 %, 15.45 to26.37%, 28.19 to 71.26%, and 11.21 to 44.23% respectively.

The calorific values and sulphur content material analysed samples ranged from 2388.024 to 9801.324 Btu/lb and <0.02 to 2.93% respectively.

From the end result obtained, the quantity of sulfur is relatively small, which will have low sulphur emission to the environment, from this it was concluded that coal has low and high quality based on calorific value and sulphur content, respectively.

5.2. RECOMMENDATION

- ❖ Thus, XRD and XRF analysis to know the mineralogical composition of coal for further constructive information on the Shela coal quality is recommended.
- ❖ As the laboratory result of the proximate analysis was shown a high amount of ash content and a low amount of fixed Carbone, this indicates it contains more impurities or inorganic content and it should be recommended that the beneficiaries of this coal should use the technique of floatation.

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