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Analysis of Fuel Properties for Peat: A Case Study

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Abstract*: The main theme of this exploration is to reveal the fuel characteristics with the value of calorific value correlation of LHV, HHV on peat based on proximate analysis at Abnali, Barasat north –east in Khulna. Actually there is a rising movement for alternative energy resources and peat is the replacement of fossil fuel as energy resources. The fuel characteristics quality of peat from Khulna to determine the proximate characteristics (moisture, ash content, fixed carbon, volatile matter) and calorific value with higher heating value (HHV) and lower heating value (LHV) by the proximate analysis. The people of this area in Abnali, Barasat called it "JOPE SOIL". By the proximate analysis the range of calorific value (cal/g) for (7094.58525-4137.89625), HHV for kj /kg (28644.10-20107.58), LHV for Kj/kg (25404.10-16867.58). Power plants of about 22-25 MW capacities may be recognized in this area based on peat of in Khulna which may be deposited more than one hundred year at present.*

Keywords*: Calorific value, LHV, HHV, Proximate analysis, Peat (JOPE SOIL)*

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I. Introduction

Gaseous, liquid, and solid fuels; chemical and the fossil fuels are the major part not only our country but also the world energy market and these are considered the main supply of thermal energy. The reserves of fossil fuel are finite and it has taken millions of years to require forming this condition in the earth. Biomass and such kinds of natural resources are only the renewable carbon reserve identified that is large sufficient to be used as a replacement and alternative for fossil fuels [1].In general case, more than 80% government of different country fuel in world subsidy is about a lot of money per year to rally its community's require about a million kilo litter for each year our country is not different from this ratio. However, for increasing a new energy sources with large value of calorific as alternative and preferable resource of energy for domestics and miniature industries, there desires tube innovative investigation. [2]

There are different natural, effective and renewable carbon resources acknowledged that is large enough to be used as a replacement of fossil fuels compound such as water- and land-based organisms, vegetation, and trees, or virgin biomass, RDF (refuse derived fuel) and all dead and waste biomass for example (Public solid waste) (PSW),bios- lids (dirt) animals and their wastes manures[1].Bangladesh is now passing such kinds of era when it needs a lot of energy par day and day by day it increasing. Actually fossil fuels and highly carbon base resources are not enough for our growing people at present and future. By reason of energy catastrophes in Bangladesh consequence from extreme utilization of fossil or relic energies, substitute energy resources must be assessed.

In our country Peat is consider as a future energies and it has reserved approximately 875 million tons (wet peat) and 125million tons (dry peat) in our country[3].The total resources for fuel use in a place approximately 275.998 million tons and total known reserves for fuel use is approximately 137.999 million tons and additional resources is also same , it is approximately 137.999 million tons in our country[4].In our country peat is neglable position because of high research on it, lake of high processing into fuels and sufficient calorific value .The two developed countries Finland and Sweden had used large amount of peat resources because it generates high power of electricity and heat and they are the optimistic symbol for us [5].

The process of supplementary efficient peat ignition methods depend significantly on numerous fuel or energy features, i.e. heating value, moisture, fundamental structures and possessions of ash etc [6] Calorific value is the largest part of significant assets and it decides the measures the assessment of peat or any kinds of fuel properties as a fuel [7][8].

However it indicates significantly that a fuel can be discovered since an inexpensive as well as ecological energy and power resource. These will be deliberated investigational or deliberated from the analysis, consequences of ultimate or proximate methods. [7][8][9]. Heat quantity is changed when a component's persuade of peat is scorched absolutely and ignition products are converted into cool towards a standard temperature of 25 degree that is called the calorific value [9].

It can be articulated as higher heating value (HHV) and lower heating value (LHV) calculated experimentally by via a bomb calorimeter. Investigational dimensions of HHV and proximate psychotherapy be cheap and entail the reasonable skilled analyst. However such kind's of correspondence may be established to forecast the value of calorific from psychoanalysis of proximate data to develop the problems.

This research aims to analyze the moisture, ash, volatile matter and carbon properties of Khulna's peats and also to create actual identification of peat's value of calorific depend on its psychoanalysis of proximate records as an alternative fuel.

II. The investigation area

The peat investigation areas are indicated on the north- east, Abnali, Barasat in Khulna district (Figure 1) and it is deposited in low-lying alluvial plain or flood plain. Actually it is one kinds of marshy or swampy land. During the peat investigations areas very wonderful peat was identified (Table 1). Actually these areas are topographically also deposited the miserable part of the flood basin. The average thickness of the peat in different places from surface approximately 0.2 m to 8m and it is very near to the surface. The people of that field visiting area are called this peat "JOBE SOIL" (Figure 2) and people use it for their cooking as a replacement of wood. These regions are submerged under water for four to six months without only the winter season in a year. In the dry season the swamp land is used as agricultural land and maximum peat are deposited in this lying agricultural land. Different types of crops have been cultivated in the peat bearing areas but production is not higher than the general field. The seven different locations are indicated here where peats were sampled from that investigation area

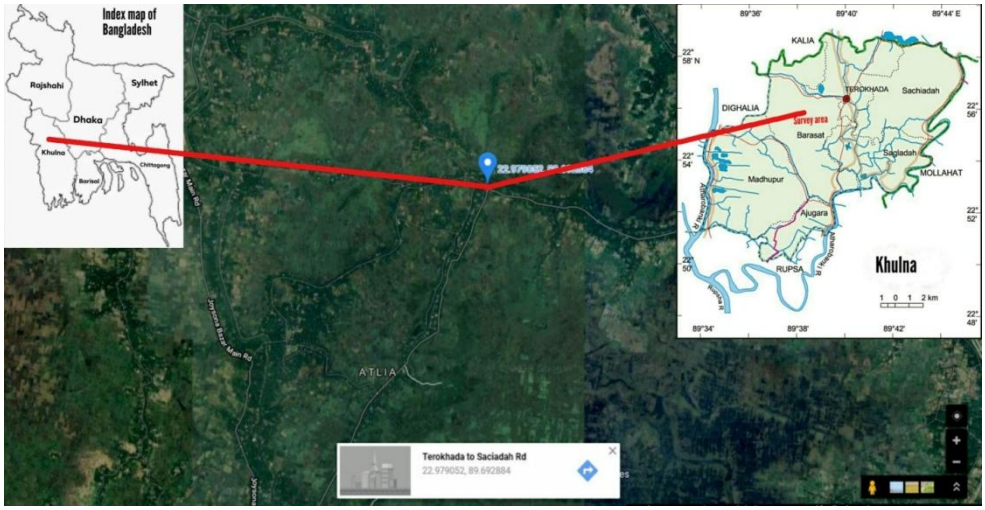

Figure 1: Map showing the location of investigation area. (Abnali, Barasat, Khulna, Bangladesh).

Location	Place	Coordinate	Depth(From Surface)in m
1	Abnali, Barasat.	N $22^0$55′53, E $89^0$39′51	0.6
2	Abnali, Barasat.	N $22^0$55′53, E $89^0$39′53	0.3
3	Abnali, Barasat.	N $22^0$55′57, E $89^0$39′51	0.8
4	Abnali, Barasat.	N $22^0$55′53, E $89^0$39′57	0.5
5	Abnali, Barasat.	N $22^0$55′59, E $89^0$39′56	0.5
6	Abnali, Barasat.	N $22^0$55′60, E $89^0$39′50	0.4
7	Abnali, Barasat.	N $22^0$55′63, E $89^0$39′52	0.5

Table 1: Seven different locations where peats were sampled

Figure 2: Initial steps of roiling peat in Abnali, Barasat as using the replacement of fuel.

III. Materials And Methods

3.1. Proximate Testing

Proximate analysis is such kinds of analysis which applied to measure the structure of moisture ingredient, fixed carbon, volatile matter and ash ingredient:, also in weightiness ratio [10][11].It is quick, beneficial, convenient, and can be operated by any competent researcher, scientist or engineer applied these common laboratory equipment by this typical experiment methods (e.g., American Society for Testing and Materials (ASTM) or European Committee for Standardization (CEN)[10], [12–14].

Moisture ingredient:

The estimation of the percentage of water extent (Moisture **i**ngredient) of biomass or peat was carried out using the normal norm by the following equation:

$$\text{Moisture ingredient (M) \%} = \frac{A-B}{A} \times 100\% \quad (1)$$

Where: A= Initial mass of peat sample (Taken 1g)

B= Mass of peat sample consequences of 107°C heat temperature. (gram)

The ash ingredient:

The computation of ash extent percentage in peat sample was redacted applying the muffle furnace the normal norm by this the following equation:

$$\text{Ash ingredient (AC), \%} = \frac{D}{A} \times 100\% \quad (2)$$

Where: D= Mass of peat sample consequences of 750°C heat temperature. (g)

Volatile ingredient:

The computation of the ratio extent of volatile material (volatile ingredient) restricted the peat had driven by using the muffle furnace the normal norm by this the following equation:

$$\text{Ingredient volatile matter (VM), \%} = \frac{B-C}{A} \times 100\% \quad (3)$$

Where: C=Mass of peat sample consequences of 950°C heat temperature (gram)

Fixed carbon:

Fixed carbon (FC) = 100 – (moisture + volatile matter + ash). (4)

3.2. Analyses calorific value

Proximate-based models have developed the HHV and LHV prediction by the bomb. Generally the prediction of value of highest heating value (HHV) and lowest heating value (LHV) through the value of calorific is measured by bomb calorimeter (heating value). Here gross calorific rate was measured by depended on the ASTM D240 standard in the model of (Bomb Calorimeter, Model: 1341, USA, 230v -50Hz).In the bomb calorimeter heat is fascinated or observed in water and equivalent energy by way of HHV and LHV can be commutated. Generally heat is based on the typical calculation in this model of bomb calorimeter .The computation using this formula of calorific value and LHV and HHV which are the main term of furl characterization.

$$Q = m.Cp.\Delta T \quad (5)$$

Where: Q: Heat absorption (kJ)
m: water mass using in the in the bomb calorimeter (gm)
Cp: Specific heat 4.186 kJ / kg °C
ΔT: temperature variation (°C)

LHV and the HHV are computed through the pursuing formula:

$$LHV = \frac{m \times C_p \times \Delta T}{m_{peat}} \quad (6)$$

The equation applied for computing HHV:

$$HHV = (T_2 - T_1 - TKP) \times (C_v \text{ (kJ / kg)}$$

$$LHV = HHV - 3240 \text{ kJ}$$

However,

$$HHV = LHV + 3240 \text{ kJ / kg} \quad (7)$$

T_1 = the cooling water temperature at bomb Calorimeter before burning (°C)

T_2 = the cooling water temperature at bomb Calorimeter after combustion. (°C)

TKP = increasing heat on the reason of combusting wire.

HHV = highest heating value (kJ / kg)

LHV = Lowest heating value (kJ / kg)

IV. Conclusion and Deliberation:

4.1. Proximate scrutiny:

Actually here performed same type's mineral resources seven sample of peat but they are different in characteristics of moisture ingredient (M), stable carbon (FC), volatile matter (VM) and ash ingredient. Again they are different in depth, GPS value and sample distance from each other. As with raw materials, the fuel quality of seven sample of peat are also symbolized through the rate of the water extent (moisture dehydrated sample in air), ash (ash extent), effortless fly material (volatile matter), solid carbon material (actual carbon), and value of calorific. Proximate analyses and calorific value restrained for apiece the samples of peat and its fuel characteristics analyses value are exposed in (table 2) and the higher and lower heating value have shown the (Figure 3)

Sample	Moisture(as received),%	Moisture(air dried),%	Ash ingredient,%	Volatile ingredient,%	Fixed Carbon,%	Value of Calorific , Cal/g
1	81.93	13	20	58	9	6287.625
2	66.97	11	28	54	7	5373.5985
3	88.76	11	16	62	11	5540.71875
4	77.37	10	36	50	4	4137.89625
5	58.64	10	20	62	8	5867.388
6	82.88	10	21	59	10	7094.58525
7	14.91	11	22	59	8	4846.63725

Table 2: Proximate analysis and calorific value of peat

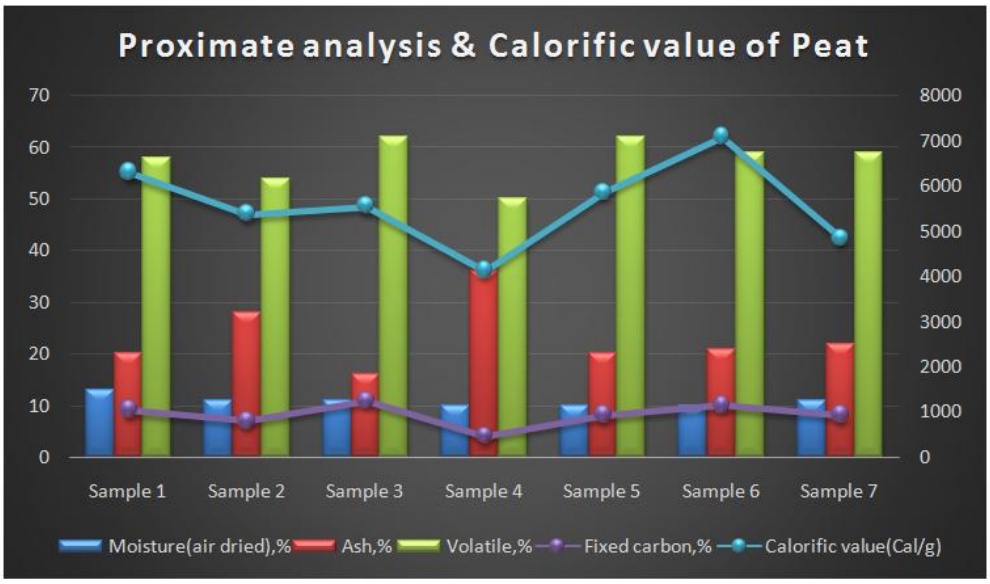

Figure 2: The combined graph of moisture (dry), ash, volatile matter, fixed carbon with their percentage and calorific value prediction.

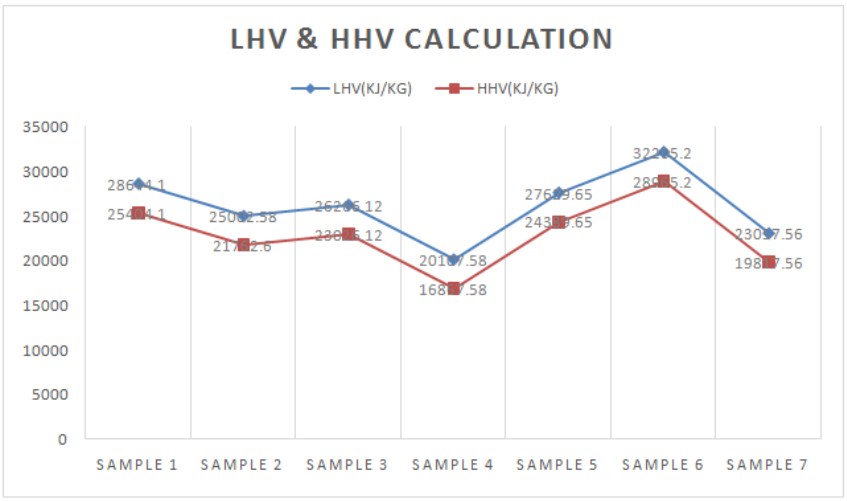

Figure 3: The higher heating value and the lower heating value's which associated with calorific values of seven samples.

The investigation peat samples by Sumatera and Kalimantan where they analyzed thousands of peat. [15], specified which more established peat and it has considered higher carbon substances and less ash extent. Peat sample are collected from Teluk Pulau, South Sumatera [16] demonstrated slightly moderate C and less ash substances than Pontianak's peat. It will be obscured that previous peat was more established than latter one. The consequences are related as peat in Eastern coast of Sumatera and Western Kalimantan remained both categorized as coastal peat and unfashionable from 7000 and 4000 cal BP[17],] which are moderately same the calorific value of Khulna. Here included that the ash ingredient of Finland's and Netherland's [18], moderately same the ash content of Khulna's peat.

4.2. Characterization of sample:

Scrutiny consequences of the samples by Proximate Analysis are dedicated in Table 1, table 2 and it has perceived that the sample possessions revolutionized in moderate assortment of discrepancy in different sample. They are: wet moisture(as received) % for (88.76-14.91),air dried moisture% for (13-10), ash% for (36-16),volatile matter% for (62-50),fixed carbon% for (11-4),calorific value(cal/g)for (7094.58525-4137.89625), HHV for kj /kg (28644.10-20107.58) ,LHV for Kj/kg (25404.10-16867.58).

4.3. Prediction Calorific Value:

The formula is applied to determine the value of calorific (Figure 2) and the consequences of performance criteria are shown with higher and lower value in the chart of graph (Figure 3)

The highlighted sample in Table 2 that has shown the best recitals of extrapolation (with the highest values of calorific) and (sample 6) is the best condition than (sample 1) ,then (sample 2) who are moderately best in all parameters of proximate analysis.

In this analysis the six equations have been highlighted here mainly considered the 1stgroup, the equations (1-4) for proximate analysis and on the other hand another considered the 2ndgroup the equations (5-8) for calorific value and HHV and LHV (Figure 3) which helped the production of calorific value. As shown in (Figure 2)the calorific value of peat samples with the value of stable carbon, volatile substances, and ash, moisture apparatuses (in wt %, dry-basis) are plotted by a single graph through using the HHV consequences contrast with different configuration of peat proximate analysis result.

In contrast, here is a well inclination if the HHV consequences diminutions the ash substances will increase as well as it damage the fuel characteristics. From the chart it also determined that stable content of carbon has a positive effect whereas ash substances observed an effect with negative on the HHV of fresh sample of peat materials [19]. During the peat incineration process since the energy of ash materializing in organics for updraft interruption and segment conversion is reserved from peat incineration process where some unfavorable effect on the evident heat attained [20].

High water content is another factor which responsible for reducing the calorific value because it decreases transformation effectiveness and redaction for the energy and it evaporates the water. On the opposition, low water levels will enlarge the competence, achievement and burring process. The water extent is the largest significant feature which impressively distresses the fuel incineration physiognomies of the peat [11]. Water ingredient has also a control proceeding inner heat which changes fuel because evaporation endothermic or the total energy required increasing the burning temperature.

At the time of combustion, water content of peat (fuel) will bury temperature for the desertion method that will impertinence the decrease value of calorific on peat .This will guide the heat into lower or burning heat to force the reaction. For this cause the burning of temperature becomes lower and the incomplete result incineration of the materials that are substances of volatile and will evidence of burning C (smoke) in the chimney. [11].

These consequences indicate that substances of ash are one of the most significant fuel properties directly distressing HHV. But the consequence of VM configuration also effected badly with the HHV or calorific value because much volatile ingredient with HHV is abundant more intricate and unimpressive [20].Correlation of proximate analysis by the determination different fuel characteristics and testing of predicting calorific value of calculated to quantity the strength of connotation between the factors fuels characteristics (Figure 2) and correlated variables (e.g., HHV, LHV)(Figure 3) [21].

Content of ash:

Ash is such kinds of substances which remain after fuel combustion. Actually it is the fuel combustion residue. If it is higher in the sample, the fuel calorific value will lower. During combustion remains ash was created from any kinds of mineral resources that are bound in carbon structure. In this research the ash comprises the contamination of the fuel. The ash extent of the fuel generally has measured through heating the fuel at a warmth of temperature is 500°C , about 1hour .[11].Ash is considered a incombustible substances. When the any types of resources (peat) are burned, at that time the volatile ingredient were called as ash. However, the elements of ash extent that has a low steaming point will vaporize at last it into convert into gas. The maximum ash content is 36% and the lowest that is 16% was observed in the Khulna's peat composition (Figure 2).

Volatile matter:

Methane, hydrocarbons, hydrogen, carbon monoxide, nitrogen and unburned gases are the main materials which are found in fuels and indicate the volatile material volatile material (VM) is resoluted by inserting and it replaced the in the muffle furnace at a temperature of 900±15° for heating during 15 minutes. The substances will disappear when the pear sample are dried at a forbidden temperatures which is called the volatile extent of peat. The ability of combustion of fuel or energy is calculated by the volatile ingredient. Volatiles ingredient means the releasing factor of vapor combustion on calorific value which is called the fuel with a high extent.

The maximum aim of volatile ingredients were established in peat of Khulna amounting to highest 62%, on the contrary the lowest levels of materials in volatile matter is identical to 50 % (Figure 2.)

Carbon content (actual amount of carbon):

The energy content and characteristics of the fuel is generally considered by the carbon content. The material of the ultimate carbon is not only same as the solid carbon (fixed carbon) of a fuel but also after the constituents of volatile (volatile extent) is liberated from the burning proceeding that is called the solid carbon (fixed carbon). Fixed carbon indicates the fuel combustion process. But they are misplaced of along with hydrocarbons high which indicate due to their volatility. Therefore, the quantity of CO_2 formed through burning of a fossil fuel and it will determine by the ultimate carbon. Fixed carbon (FC) of peat made a correlation of other material in fuel characteristics that will be propagated from the sample of a fuel material. However, the mass of volatile ingredient helps for determining the actual carbon which is generally subtracting, moisture ingredient and ash ingredient of the actual weight sample a peat of fuel or generally acknowledged as by difference from sample to sample [11].The level of the higher value in fixed carbon is 11% and the lower value is 4% (Figure 2).

V. Conclusion

From the calculation it understand that fuel characteristics of peat are expressively allied on its HHV, LHV (Figure 3) and the other main parameters are moisture, ash, volatile, ingredient fixed carbon and value of calorific(Figure2).All parameters are calculated by the proximate analysis which is cheap and low costing and time saving analysis. In this research calorific value's range is (7094.58525-4137.89625)cal/gm which indicates the Khulna's peat is moderate to best for alternating use of fuel. Again this peat also applied in household use, small industrial purpose and also approximately 22-25 MW base power plants may be run. If we mine (avoiding environment hazards) this peat, we will make a sustainable economy in Bangladesh.

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