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Characterization of Peat for Identifying the Effectiveness as Energy Source by Proximate Analysis

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Abstract

Energy crises have posed a great threat to Bangladesh. In recent years, many researchers have focused on the invention of an effective nonrenewable energy source. Among all the natural resources in Bangladesh, peat is the one. In this current study, a proximate analysis was done in the laboratory to measure the calorific value, moisture content, ash content and volatile rate of the peat collected from the North-Easter part (Chatal beel, Moulavibazar, Sylhet) of Bangladesh. Actually, the whole country is moving for an alternative energy source and the replacement of fossil fuel is peat as an energy source. The proximate analysis was used to the characterization of the peat, because of its low experimental cost. By the analysis of the research samples, the range of calorific value (kcal/kg) for (2226.66-3243.888), volatile matter as a percentage (6.83-48.44), ash content as a percentage (52.59-93.15) and moisture content as a percentage (19.76-50.33). Overall, the values were indicated the effectiveness of peat as an alternative energy source.

Keywords: *Nonrenewable energy; Peat; Proximate analysis; Energy source.*

1. Introduction

Bangladesh is rich in natural resources, which cover 148,460 km^2 areas with 130,170 km^2 dry land areas and 18,290 km^2 water areas [1]. It has a momentous amount of natural gas with 27 gas fields [2]. But it is not enough to fulfill the total energy demand in Bangladesh because the energy demand in every sector is increasing day by day with the population growth [3].Among the gaseous, liquid and solid fuels, chemical and fossil fuels take a remarkable part in the whole world's energy market and these are considered as the principal supplier of thermal energy. Biogas and these natural resources are only the replacement and alternative of fossil fuels [4-5]. In the ordinary case, approximately a million kilo liter of fuel in required for the country community and more than 80% government of country fuel in the world auxiliary is about a lot of money. Both amount ratio is not different [5-6].However, with the growing gas crisis and increasing, new energy sources with the great value of calorific as an alternative and preferable resources of energy for household and handy industries, their desires tube switch investigation, Bangladesh is moderately moving its initial energy focus from gas to coal [3,5,6]. The government is trying to give full effort to find out a cheaper and more reliable replacement for coal [3]. Peat is the initial stage of the coal formation.

Several naturals, effective, and renewable carbon resources recognized that are great enough to be used as a replacement for fossil fuel. Bangladesh is required a lot of energy in this present era and the requirement is increasing day by day [4-5]. But at present, fossil fuels and highly carbon based resources are not enough to fulfill the total energy demand for the growing population [5].

After finishing the life time of plants and trees, their leavings submerged to the bottom of the wetland, which covered by vegetation, gathering together layer upon layer and finally forming a pulpy, semi liquid material named peat. It is the preliminary stage of coal and has a perfect carbon trace, low sulfur content and high calorific value [7]. It is depicted as thin to thick bedded and the range is 0.5 m to 8 m, brownish black to black in color, mature as well as the chemical analysis of the peat discloses that the heat creating value is high with the presence of high carbon content, low ash content and low sulfur content. Bangladesh has significant quantities of natural resources like natural gas, oil, coal, peat etc. Among them, peat is used all over the country in some small power plants to meet the required energy demand. Peat is one of the important mineral resources in Bangladesh both economically and geologically [8]. In this circumstance, experts discussed with the energy sector believe that peat coal could be a realistic alternative for this energy-hungry country. The Geological Survey of Bangladesh (GSB) has detected respectable amounts of peat deposits in different locations of Bangladesh, most notably at Baghia-Chanda beel in Madaripur, Kola Mauza in Khulna, and Pagla and Salla of Sunamganj. A huge amount of peat coal has already been discovered at Chatal beel in Hakaluki haor of the greater Sylhet division by the GSB. Chatal beel is the largest dry peat reserve of Bangladesh [3]. Maximum peat coal is used to generate electricity. But all the physicochemical properties of peat are not the same. So, the characteristics of the sample peat are not the same also.

In Bangladesh, peat looks like future energies because near about 875 million tons (wet peat) and 125 million tons dry peat is there [9]. Approximately 137.999 million tons of resources are used within 275.98 million tons of total energies, and additional resources are approximately the same as the amount of used fuel [10]. In our country peat is in a negligible position by lacking proper utilization. The two developed countries Finland and Sweden, have used a huge amount of peat because of its generating power of electricity and heat and they are the optimistic symbol for us [11].

The process of supplementary economic peat ignition strategies relies considerably on varied fuel or energy options, i.e., heating worth, moisture, basic structures and possessions of ash etc. [12]. Calorific value is that the largest a part of vital assets and it decides the measures the assessment of peat or ant types of fuel properties as a fuel [13-14].

However, it indicates considerably that fuel may be discovered since a reasonable likewise as ecological energy and power resource. These are going to be deliberated investigational or deliberated from the analysis, consequences of final or proximate strategies [13-15]. The heat amount is modified once components persuade of humate is scorched completely, and the ignition merchandise area unit regenerates into cool towards a regular temperature of twenty five degrees that's known as the hot price [15].

In order to perform the identification of a feasible characteristic of peat coal, proximate analysis has to perform on collected peat samples. The previous steps are normally to collect the samples from different locations of peat reservoirs. In the current study, the proximate analysis is done based on the combination of moisture content, ash content. volatile matter & calorific values and these values are combined to determine the exact characteristics of the peat samples of Moulvibazar district on the Chatal beel area in Bangladesh.

2. Location of the investigation area:

The peat research areas are pointed out in the North-Eastern Bangladesh, Chatal beel, Hakaluki haor, Moulvibazar in Sylhet district [Figure 1] [16]. HakalukiHaor, one of the largest wetlands of Bangladesh, has a deposit of Peat found in a survey conducted by Geological Survey Bangladesh (GSB). It is one of Bangladesh's largest and one in every of Asia's larger marsh wetland resources. Hakaluki haor is delimited by the Kushiara stream likewise as a locality of the Sonai bardal stream to the north, by the Fenchuganj- Kulaura railway to the west and south, and by the Kulaura-Beanibazar road in the east. It lies between 24°35′ N to 24°44′ N and 92°00′ E to 92°08′ E [16-17]. Actually, these area units are topographically additionally deposited the miserable a part of the flood basin. The typical thickness of the peat in different places from the surface or so 0.2 m to 8m, and it's terribly around the surface.

The area of this haor covers agricultural lands, river channels, grassy and plain lands, and a lot of beds. Crops are cultivated in the dry season in that location from where peat samples were collected but, the production was not as good as a normal field. Chatal bed lies as one of the 40 water bearing formations of the haor. The study area is 8 meters above sea level. The four sampling points with their coordinates are given in Table 1.

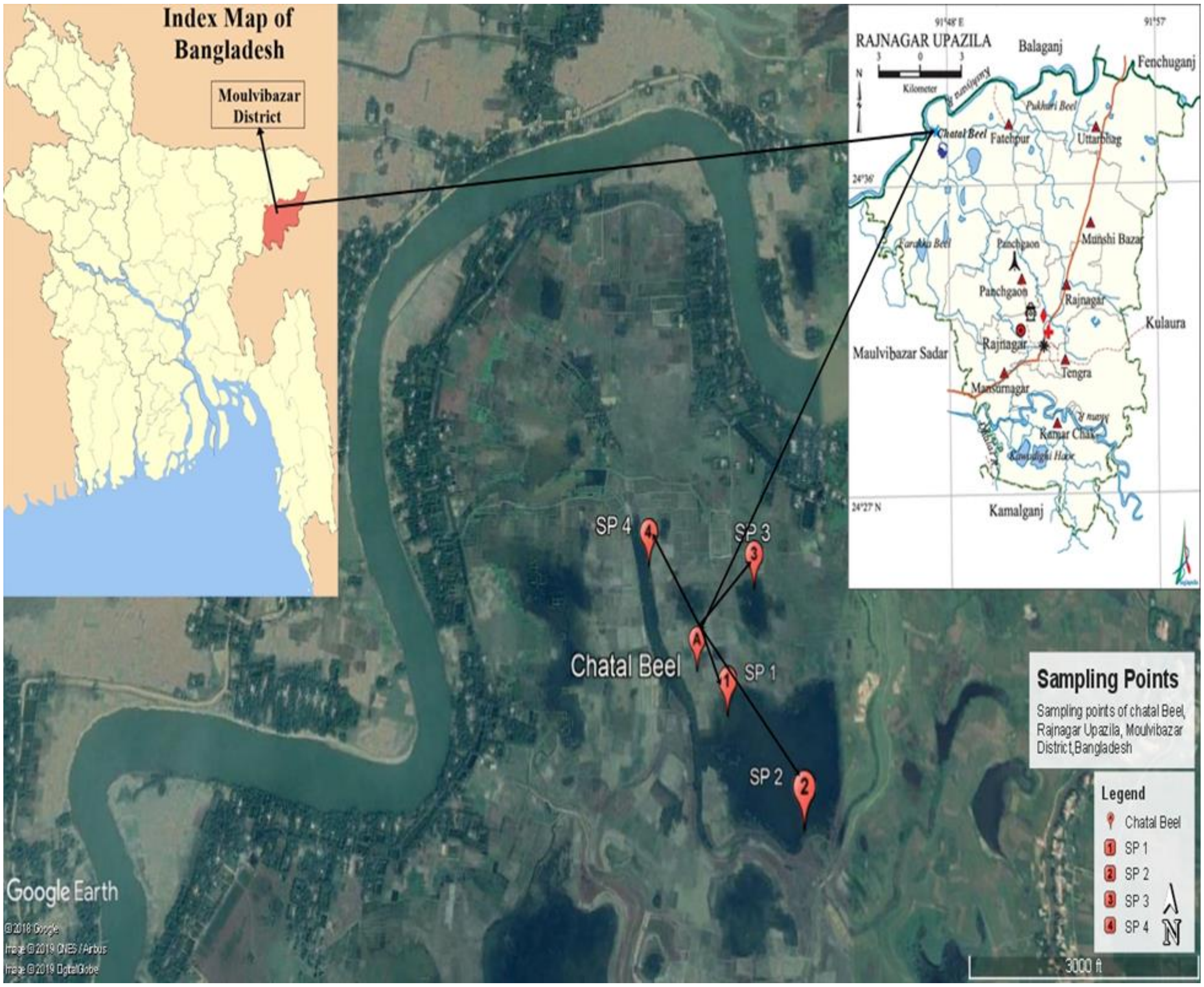

Figure 1 Map showing the location of the study area

Table 1. Four different locations from where peat was sampled

Location	Place	Coordinate
1	Chatalbeel, Hakaluki haor	N 24°37’40.17”, E 91°47’47.35”
2	Chatalbeel, Hakaluki haor	N 24°37’29.61”, E 91°47’58.07”
3	Chatalbeel, Hakaluki haor	N 24°37’52.58”, E 91°47’51.99”
4	Chatalbeel, Hakaluki haor	N 24°37’54.79”, E 91°47’35.82”

3. Experimental section

The study is mainly based on geochemical analysis, and solid fuel properties are gathered from the experimental samples which are collected from the field. The sample collection areas were carried out in Maulvibazar district, Bangladesh. This methodology includes the following steps:

3.1. Field sample collection

The peat samples were collected from several locations of the Chatal beel of Hakaluki haor, Moulvibazar, Bangladesh. These collected four samples were from different depths, which vary from .5 to 7 meters in different stations. The first two samples were from location-1 which is mainly 1 foot below in the sub surface. These samples included traces of clay layers alongside the peat samples. The latter two samples from location-2 were samples of deeper depth which were comparatively better samples of peat. Samples were collected with samplers much carefully and taken to the laboratory for preparation.

3.2. Sample preparation

The sample preparation for most of the proximate analysis included mainly drying and crushing the samples to a fine grained powder phase. The samples selected were dried in the laboratory with a temperature of 110°C. Samples were dried with a time estimation of 3 hours inside the oven in the mentioned temperature. After that, they were cooling down at room temperature in the laboratory by dedicator. Only for the measurement of the moisture content, the weights of the sample (gm) were taken before drying and after drying. Then the dried samples were crushed with the help of a hand motor in the IMMM Laboratory. Finally, the samples were ready for analysis.

3.3. Experimental procedure

The samples experimented with the standard procedures for proximate analysis.

4. Data analysis

The following steps are included in completing data analysis.

4.1. Proximate analysis

Proximate analysis is that which is applicable for measuring the structure of moisture ingredient, fixed carbon, volatile matter, ash ingredient, and weightiness ratio [5,18,19]. This analysis is very fast, advantageous, suitable, and operated by any efficient researcher; scientists or engineer applied this common laboratory equipment by this typical experiment method, e.g., American Society for Testing and Materials (ASTM) or European Committee for Standardization (CEN) [5, 18, 20-22]. All the process analysis was done at the IMMM Laboratory, BCSIR, Joypurhat.

a. Moisture content analysis

For analyzing moisture content oven, precision balance, and analytical balance with having an accuracy of 0.0001gm were required. At the beginning of this analysis, samples were weighted with the precision analytical balance and the weight was noted down for every sample. Then the weighted samples were air-dried in the oven for 3 hours at a temperature of 110℃. Again, the dried samples were weighted with precision balance and the values were noted down.

b. Ash content analysis

Standard Followed: ISO 1171. Muffle Furnace, Porcelain Crucibles, Precision balance, and analytical balance with an accuracy of 0.0001 gm were used for this analysis. Firstly a 30 ml clean and dry crucible was taken and measured, and its weight was noted. The milled air dried peat sample with 1±0.1 gm was taken in the crucible. It was brought to a cold muffle furnace, and the following temperature program was run through the heat to 250℃, 500℃ and 815℃ for 30 minutes, 30 minutes and 60 minutes respectively. Again, repeat the last temperature program. The furnace was shut down, and the crucible was taken out and allowed for cooling at ambient temperature for 15 minutes. Then the crucible was put into desiccators (without desiccants). After cooling at room temperature, it was weighted. Parallel determinations were made and it was checked that the difference should not have varied more than 0.2%.

c. Volatile matter analysis

Standard followed: ISO 562. Muffle furnace, Fused silica crucible 50 mL with lid, Desiccators (empty), Precision balance, and analytical balance with an accuracy of 0.0001 gm were required for this analysis. 1±0.01 gm of the milled air-dried sample was weighted in a previously glowed out weighted fused silica crucible closely fitting ground lid. They were put in a hot muffle furnace (900°C), and the door was closed quickly. They were held for 7 minutes. After that, they were taken out from the furnace and ere allowed for cooling at the ambient temperature for 5 minutes. Next, they ere was put in a desiccator for further cooling at room temperature. Finally, the measured weight of crucible and its contents were taken.

d. Calorific value determination

Standard followed: ISO 1928:1995 and IS 1350: part II. Bomb calorimeter, oxygen gas cylinder, water, precision balance, and analytical balance with an accuracy of 0.0001 gm are required for this analysis. Exactly 1 gm of milled air dried sample was weighted in the bomb crucible and torched by the electric potential for over 30 minutes. After getting the standard temperature rise of the cooling water, the bomb was dismantled.

5. Results and discussion

The properties supported the analysis of peat typically rely on the geology, hydrological characteristics of the wetland, and degree of organic decomposition. Proximate analysis values have their own importance to outline the standard of this solid fuel.

The analysis was done based on the proximate analysis, the values of moister content, ash content, volatile matter, and calorific values are compared to the standards values. Perscrutation consequences of the samples by Proximate Analysis are indicated in Table 2.

Finally, the collected peat samples were compared with peats of different areas of Bangladesh.

Table 2. Proximate analysis of different samples

Sample no.	Moisture content (%)	Ash content (%)	Volatile matter (%)	Calorific value (Kcal/Kg)
p-1	19.76%	93.15%	6.83%	2314.158
p-2	19.85%	92.32%	7.74%	2226.660
p-3	50.33%	53.65%	47.37%	2716.086
p-4	48.97%	52.59%	48.44%	3243.888
Average	34.73%	72.93%	27.56%	2625.198

5.1 Proximate analysis

a. Moisture content value

Moisture content value has significant importance in the analysis of any kind of peat. Peat samples with higher moisture content are not good for usage purposes. Burning of peat has a direct relationship with the moisture percentage, as the lower percentage is expected widely. Because if there is excessive moisture, a huge amount of heat is wasted to reduce it. That reduces the calorific value. Moisture is usually determined as total moisture, calculated as the loss of weight between the untreated and analyzed samples.

The moisture content for peat generally varies from 40-50%. The Table 2 shows that the average moisture content of the peat samples here is 34.73%. This is a low moisture value for peat and can be compared to be designed as lignite, as lignite has been found with moisture content as high 30-70% around the world [23]. This lower value of moisture content is an indicator of these samples to be good quality peat or brown coal (lignite). Figure 2 indicates that the moisture content of peat samples varies within 19.76% to 50.33%.

b. Ash content value

Ash content is another important property for measuring the solid fuel property of different ranks of peat. Ash content of peat is the non-combustion residue left after peat is burnt. It represents the bulk mineral matter after carbon, oxygen, sulfur, and water (including from clays) have been driven off during combustion.

The more the ash residue is present after the ignition, the more critical the usage of peat would be. Excessive ash makes the valuation and quality peat lower in rank. Because of the usage in power plants and other industries, the equipment will have a disruptive operation because of unneeded residue. Ash reduces the calorific value of peats. And so, burning peats on a large scale requires knowledge of their ash contents.

The ash content of peat has been a range defined from 2 to 15% [24]. Where lignite has a starting range of ash content from 6% to 10%. But for the collected samples, ash content we have on average is 72.93%, which is a bit high in value. Among the collected four samples, the values for 3rd and 4th samples are 53.65% and 52.59% respectively, which can be express in the better range from samples 1 and 2.

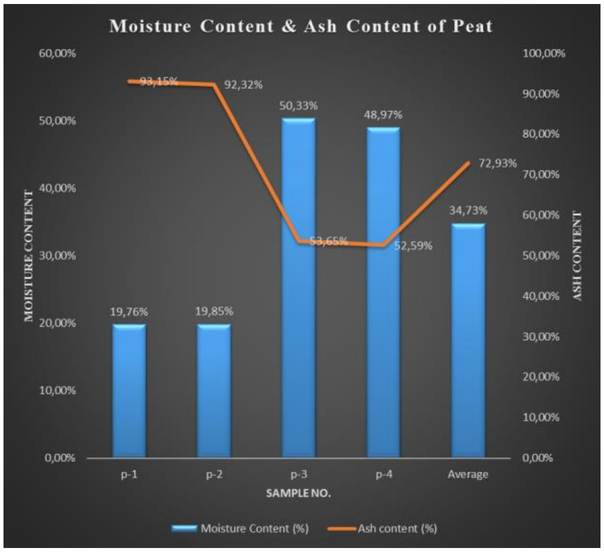

Figure 2. The combined graph of moisture content and ash content with their percentage of the peat samples

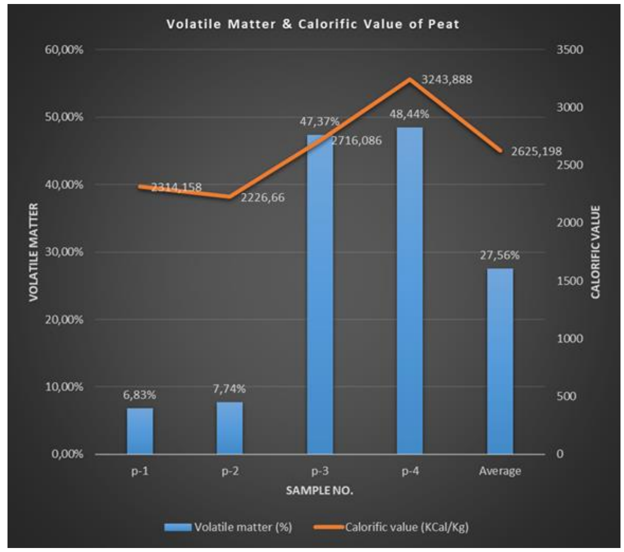

Figure 3. The combined graph of volatile matter and calorific value with their percentage of the peat samples

c. Volatile matter percentage

Volatile matter in peat and coal refers to the components of coal, except for moisture, which is liberated at high temperature in the absence of air. This is usually a mixture of short- and long – chain hydrocarbons, aromatic hydrocarbons and some sulfur.

The percentage of volatile matter has an influence on determining the quality of the peat. When the volatile matter of the blended peat is low, flame stability decreases (continuous support of oil may be required for normal operation). Sample peats were blended by hand motor.

The average value of the volatile matter is 27.56%. As to know from the standard values, the volatile matter is 60-70% in peat and lignite and sub – bituminous series. The percentage is 50-60% [24]. Which defines our grade of peat is lower than standard values.

d. Calorific value

The calorific value is the amount of energy produced by the complete combustion of a material or fuel. It is measured in units of energy per amount of material.

The laboratory analysis of peat defines the energy produced as heat from the complete combustion in ambient temperature. Based on the calorific value, the rank of peat is decided mainly, as the calorific value is the prime parameter when it comes to the usage purpose.

The ranks of peat are defined as based on the calorific value. The standard calorific value for peat presents between 4780 Kcal/Kg to 5497 Kcal/Kg, and for lignite, the value is 4780 Kcal/Kg to 5736 Kcal/Kg [24]. From the analysis of peat samples, the average calorific value is 2625.198 Kcal/Kg, which defines the grade of peat is lower than standard values, but later it was compared with the other calorific values of peats from different peat fields in Table-3 and indicated the effectiveness of the sample peat.

Calorific value is the most important property when it is time to compare different peat mines in Bangladesh. With collected samples showing calorific value, it is medium comparable with other values in the table. So, we can say that our sample also good for producing energy for industrial purposes.

5.2. Discussion

The analysis had done based on the percentage of peat contents. These values are used all over the world as a random standard for peat utilization.

We had some of our proximate analysis properties better than the rank of peat. With the moisture content of 52%, high grade peat should be a designation for this property. With the good values of volatile matter and good calorific values, these samples have shown enough lignitic properties. A calorific value of around 4000 Kcal/kg is obviously a good experimental value in the analysis of this decomposition organic based fuel.

Ash content has been always a concern when it comes to the usage purpose of solid fuel. With comparatively higher ash content (46%), more samples should have been observed to reach a better conclusion.

Table 3. Comparison with peat analysis values collected from other areas of Bangladesh

Peat found	A.C. (%)	M.C. (%)	V.M. (%)	C.V. (Kcal/Kg)
Catalbeel (Bangladesh)	72.93%	34.73%	27.56%	2625.198
Madaripur- Gopalganj (Bangladesh)	5.6 (received) 12.44 (dry basis)	84.10 (received) 65(dry basis)	N/A	694.6(received) 1308.8 (dry basis)
Barapukuria (Bangladesh)	12.10	2.73	28.70	6680
Barasat- Khulna (Bangladesh)	23.29	67.35(received) 10.86(dry basis)	57.71	5592.664

We have been familiar with 2(two) different classification systems, Indian Standard Institute Classification and the ASTM Classification of coal. The Indian standard method has not been our focus as we did not consider the yield volatile matter and caking nature of the coal. Though reflectivity was not our field of focus as well, we used the later classification system based on volatile matter and calorific value. The classification system has also followed the graphical chart based on these properties.

Peat and lignite are used widely for cooking, domestic purposes, brick fields and power generation. With an estimated reserve of peat of 282 million tons in wet condition and 112 million tons in dry, the reserves of this good quality peat can be used to accelerate the development in electrical power supply with some constant 100 MW power stations for a hundred years. Many countries, especially in Europe and Northern Europe, are using peat for producing electricity and using industrial heating purposes.

Growing demands at the world are going with the vibe to use more peat for energy purposes. As we are not too dependent on peat based power industries, the future of the world will be in huge reliability to produce energy from peat reserves.

6. Conclusion

From the laboratory test results and calculation, it understands that the firing characteristics of peat are present within lower to moderate in the research area and the main parameters are moisture content, ash content, volatile matter, and the calorific value. Proximate analysis is done for calculating all the parameters because of its cheap and lower cost with time saving character. In this research, the calorific values range is (2314.158 - 3243.888) Kcal/kg. This value indicates that the quality of the Chatal beel's peat is low to moderate for a substitute use of fuel. If we extract the peat and make it suitable for application in the power plants avoiding all natural hazards, it can be able to create a viable economy in Bangladesh.

References

[1] Bangla Bureau of Statistics 2011; the World Factbook 2018
[2] Petrobangla Annual Report 2017
[3] The Independent, 25 September, 2016
[4] Klass DL. Biomass for Renewable Energy, Fuels, and Chemicals. Entech International, Inc., Barrington 1998, Illiois, U.S.A.
[5] Ahmed MT, Hasan Y, Islam S, Rahman M. Analysis of Fuel Properties for Peat: A case Study. IOSR Journal of Applied Chemistry, 2019; 12(5): 26-43.
[6] ES Hasan, MJding, Mashuni, WOS Ilmawati,Wa Wati, I Nyoman Sudiana (2017). Proximate and the Calorific Value Analysis of Brown Coal for High-Calorie Hybrid Briquette Application. Journal of Physics: Conf. Series, 2017; 846: 012022.
[7] McGraw Hill Encylopedia of Science & Technology, no. 4, 9th edition, McGraw Hill, 2002.
[8] Masum M, Khan MOF, Haque MdN, Hasan MdF, Sayem ASMd, Hossain MdA. Peat Resources, Condition of Deposition as Well as their Utilization, HakalukiHaor, Moulvibazar and Sylhet District, Bangladesh. International Journal of Science, Technology and Society; 2014; 2(6): 210-215.
[9] Bangladesh National Conservation strategy (2016-2031). Part-01: Executive Summary. Section: 7.8. Energy and minerals-Peat resources. Pp.49-51.
[10] United Nations statistics division. Source: Energy Statistics Database. Country: Bangladesh. Year: 1990-2004.
[11] Setyawati W, Damanhuric E, Lestaric P, Dewic K. Correlation equation to predict HHV of tropical peat based on its ultimate analyses. Procedia Engineering, 2015; 125: 298-303.
[12] Changdong S, Azevedo JLT. Estimating the higher heating value of biomass fuels from basic analysis data. Biomass and Bio-energy, 2005; 28(5): 499-507.
[13] Shirazi AR, Bortin O, Eklund L, Lindqvist O. The impact of mineral matter in coal on its combustion, and a new approach to the determination of the calorific value of coal. Fuel, 1995; 74(2): 247-251.
[14] Erol M, Haykiri-Acma H, Kucukbayrak S. Calorific value estimation of biomass from their proximate analyses data. Renewable energy, 2010; 35(1): 170-173.
[15] Majumder AK, Jain R, Banerjee P, Barnwall JP. Development of a new proximate analyses based correlation to predict calorific value of coal. Fuel, 2008; 87(13-14): 3077-3081.
[16] Nixon Talukder and Sanzida Murshed, "Hakaluki Haor", Banglapedia.
[17] Choudhury GA, Nishat A. Hydro-meteorological characteristics of Hakaluki Haor. IUCN Bangladesh; SEMP; UNDP; Bangladesh, Ministry of Environment and Forest 2005, ISBN 984-8574-23-9
[18] Yang Yin Ch-Y. Prediction of higher heating values of biomass from proximate and ultimate analyses. Fuel, 2011; 90(3): 1128–1132.
[19] Sukarta IN, Sastrawidana IDK, Ayuni NPS. Proximate Analysis and Calorific Value of Pellets in Biosolid Combined with Wood Waste Biomass. Journal of Ecological Engineering, 2018; 19(3): 185-190.
[20] Cordero T, Marquez F, Rodriguez-Mirasol J, Rodriguez JJ. Predicting heating values of lignocellulosics and carbonaceous materials from proximate analysis. Fuel, 2001; 80(11): 1567–1571.
[21] Quiroga G, Castrillón L, Fernández Y, Marañón E. Physico-chemical analysis and calorific values of poultry manure. Waste Management, 2010; 30(5): 880–884.
[22] Küçükbayrak S, Dürüs B, AE Meríçboyu, Kadioglu E. Estimation of calorific values of Turkish lignites. Fuel, 1991; 70(8): 979– 981.
[23] Blaschke W. Przeróbka węgla kamiennego - wzbogacanie grawitacyjne. Kraków, PL: Instytutu Gospodarki Surowcami Mineralnymii Energią, 2009 ISBN: 978-83-60195-03-1.
[24] Andriesse JP. Nature and Management of Tropical Peat Soils. FAO Soils Bulletin, 1988,59. Rome: Food and Agriculture Organization (FAO) of United Nations.

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