Ultimate and Proximate Analysis of Coal Briquettes from Lakhara Lignite, Biomass and Plastic Waste

ISSN (e) 2520-7393
ISSN (p) 2521-5027
Received on 27th Nov, 2018
Revised on 24th Dec, 2018
www.estirj.com

Sanwal Hussain*, Suhail A. Soomro*, Shaheen Aziz*, Ahsan Ali*, Naveed Ali*

**Mehran University of Engineering and Technology, Jamshoro, Sindh, Pakistan*

Abstract: Coal is available globally in abundance and is a major source of energy in many countries. Lignite coal is one type of coal that emit pollutants and have adverse impacts on environment. As Pakistan also have huge deposits of lignite coal. It is necessary to utilize coal in environmentally friendly manner. In this research, efforts have been taken to prepare low emission coal briquettes. Lignite coal from Lakhara mine in Sindh, Pakistan. Waste plastic what's more, bio waste resources (PET containers, polythene sacks, sawdust, rice husk) are utilized. Materials were carbonized, crushed and utilized in different ratios with limestone residue and guar powder as binder to create Solid fuel briquettes. The briquettes were portrayed by testing for heat content, moisture level, volatile and ash content utilizing proximate and ultimate examination. Briquettes created by this strategy are great choice to fuel wood for open air and indoor cooking and for alleviation of deforestation, desertification, and natural contamination and debasement. Reusing of the plastic leftover into refuse derived fuel by assimilation in these bio coal briquettes demonstrates extraordinary assurance and could be considered as a piece of waste administration choices particularly in the underdeveloped nations.

Keywords: *Lignite coal, Briquettes, Ultimate and Proximate Analysis, Biomass, Plastic waste*.

1. Introduction

One of the real difficulties experienced in many parts of the world these days, particularly inside the underdeveloped countries, is the deficiency of flawless and moderate fuel for family unit cooking and other modern exercises. In these nations, larger part of the natives can't manage the use of lamp fuel, gas or electricity for cooking. The situation has prompted the unpredictable felling of trees and devastation of woodland for use as fuel wood or charcoal [1]. For instance, in Pakistan a great many families inside the nation in urban and for the most part in provincial zones depend fundamentally on firewood or charcoal for their cooking and other vitality needs [2,3]. This has brought about an across the nation deforestation with the pro issues of desertification and other characteristic debasement, for example, a dangerous atmospheric deviation and loss of indispensable biodiversity [4,5]. Another angle of natural debasement is the erratic dumping of household and metropolitan waste. In most underdeveloped countries, there are no strict enactments or waste organization strategies set up to mitigate the negative effects of waste disposal [6]. Polythene things are generally used as sacks and are discarded imprudently along the streets consequently annihilating the magnificence of nature and causing ordinary flooding because of blockage of wastes and water ways [7]. Different waste that are begun in huge sum and establish natural disturbance, for example, sawdust from wood preparing shops and a couple of rural wastes, for example, rice husks [8,9]. Generation of solid fuel, for example, low emission briquettes from squanders that are promptly accessible is one of the approaches to address the negative ecological outcomes related with high use of fuel wood, waste generation and administration. These issues are of wonderful concern especially in the developing nations [10].

Composite coal briquette could be a great root of energy used for household cooking and industrial purposes. Mixing of biomass and coal for generation of the briquettes give items unrivaled quality, for example, incredible ignition properties contrasted with the use of the rough coal or sawdust alone.

In 2017, Nwabue et al.[11] produced briquettes of bituminous coal by incorporating plastic waste in addition to biomass. Varying proportion of materials are mix together to produce solid fuel briquettes. Briquettes produced with ratio of 70% coal, 8% lime, 10% plastic were in good quality in term of burning. Brand et al.[12] briquettes quality is analyzed which are produced with varying ratio of different biomasses 30, 60, and 10 % rice husk, hull and ash respectively it has good properties. Montiano et al.[13] the influence of five types of sawdust were studied when it was blended with a non-caking coal to produce briquettes. It investigated that biowaste and coal has less fluidity. Gug et al.[14] recycled plastic waste from municipal solid waste stream and utilized it as a solid energy fuel. Different types of plastic are used in this research. The impact of wood paper and other trashes are also investigated. Massaro et al.[15]used LDPE as a binder to produce coal briquettes of waste coal fines particles. These briquettes are economic and ecological substitutes to fulfil basic fuel needs.

In our scan for techniques for creation of ecologically benevolent solid fuel choices to fuel wood, we have thought that it was promising to consolidate plastic wastes and bio-waste materials with coal really taking shape of

Corresponding author Email address: *sanwalpg@gmail.com*

low discharge bio-coal briquettes with low emission and great heating value.

This paper reports our discoveries within the utilize of lignite coal, sawdust, rice husk waste, polythene wastes for generation of low emission briquettes with great fuel properties, combustion characteristics, eco-friendly and adequately larger heat contents.

2. Methodology

2.1 Equipment/Methods

Carbon, Hydrogen, Nitrogen and Sulphur is determined by using CHNS analyzer (Thermo Nicolet Flash EA 1112 series), available at National center for excellence in analytical chemistry, University of Sindh, Jamshoro, Pakistan. Briquettes combustion is carried out in Electric Muffle Furnace (Nabertherm Furnace) available in water research laboratory, chemical engineering department, Mehran UET Jamshoro, Pakistan. Briquette emission analysis is observed by Flue Gas Analyzer (Model 350XL Testo) available at Chemical engineering department, Mehran UET, Jamshoro, Pakistan. The proximate examination of samples was carried out by (ASTM 20111) methods.

2.2 Briquette materials

Lignite coal was taken from lakhara coal mines from Sindh province of Pakistan. Plastic waste materials that is used in this research (used plastic bags and bottles) and wood waste, rice husk was obtained from distant locations of Hyderabad city, Sindh. However, wood sawdust of anonymous tree, is taken from wood market at a very less cost in Hyderabad Sindh, Pakistan. Gauar powder which we used as binder is taken from tower market Hyderabad.

Figure 1 Briquette machine

2.3 Preparation of coal sample

The sample lignite coal containing amount of 2 kg was put into muffle furnace and temperature raised to 400^0C for one hour. After one-hour coal sample were taken out and quenched with water and let them to coal down. Coal sample were than crushed and stored for later use.

2.4 Preparation of biomass waste mixture

Biomass (sawdust and rice husk) were carbonized the mixture of two biomass (1:1) ratio, 2 kg were packed and placed in chamber of muffle furnace and temperature upto 300^0C for 1 hour. After that the sample were taken out, quenched with water and dried, crushed them and stored for later use.

2.5 Plastic waste preparation

Plastic waste (PET bottles and polyethylene bags) were sun dried for 2 to 3 days and cut into smaller pieces with the help of succor and then weighted equal ratio (1:1).2 kg plastic waste mixture was placed into furnace at maximum temperature of 250^0C for 40 minutes. After that sample were taken out and quenched with water to cool down and stored for later use.

2.6 Briquettes Preparation

Hydraulic jack operated briquette machine was used to produced briquettes. The machine is available at chemical engineering department Mehran university of engineering and technology Jamshoro Sindh, Pakistan. The briquette compression pressure is not recorded but it is less than 4 TON. The prepared sample were thoroughly mixed by varying quantities and a paste like substance was made by mixing of all these constituents and then this paste like substance filled in mold of briquette machine and briquettes were made by pressing through hydraulic jack. Afterwar, they dried in an oven for 1 hour at 100^0 C.

Figure 2 Coal briquettes

Table 1Percentage of composition of briquette samples

Constituent%	B 00	B 10	B 20	B 30	B 40	B 50	B 60	B 70	B 80	B 90
Coal	0	10	20	30	40	50	60	70	80	90
Biomass	80	70	60	50	40	30	20	10	0	0
Plastic	10	10	10	10	10	10	10	10	10	0
Guar powder	10	7	6.5	6	5.5	5	4.5	4	3.5	3
limestone	0	3	3.5	4	4.5	5	5.5	6	6.5	7

Key:		
B00	=	Briquette of 0 % coal
B10	=	Briquette of 10 % coal
B20	=	Briquette of 20 % coal
B30	=	Briquette of 30 % coal
B40	=	Briquette of 40 % coal
B50	=	Briquette of 50 % coal
B60	=	Briquette of 60 % coal
B70	=	Briquette of 70 % coal
B80	=	Briquette of 80 % coal
B90	=	Briquette of 90 % coal

Table 2 Ultimate analysis of samples

Sr #	Sample	% Nitrogen	% Carbon	% Hydrogen	% Sulpher
1	**Coal**	0.22	52.658	3.982	4.789
2	**Sawdust**	0.12	46.35	5.95	0.30
3	**Rice husk**	0.45	40.09	6.02	0.42
4	**PET bottle**	0.43	56.38	5.64	0.82
5	**Plastic bags**	0.45	81.80	12.32	1.89

Table 3 Ultimate analysis of blended sample

Sr #	Samples	% Nitrogen	% Carbon	% Hydrogen	% Sulpher
1	**B 00**	0.000	54.430	0.000	3.691
2	**B 10**	0.000	54.001	0.000	3.202
3	**B 20**	0.000	50.267	1.843	2.993
4	**B 30**	0.000	52.134	0.054	2.540
5	**B 40**	0.000	53.808	2.080	2.261
6	**B 50**	0.000	55.430	2.328	2.216
7	**B 60**	0.000	55.213	2.361	1.706
8	**B 70**	0.000	52.274	2.318	1.700
9	**B 80**	0.000	58.261	2.454	1.239
10	**B 90**	0.000	56.470	2.001	0.977

Table 4 Proximate analysis of samples

Sr #	Sample	Moisture %	Volatile matter %	Ash %	Fixed Carbon %
1	**Coal**	32.24	28.66	9.40	26.54
2	**Sawdust**	11.35	92.80	0.94	5.48
3	**Rice husk**	7.40	65.36	0.90	5.98
4	**PET bottle**	0.21	95.20	0.25	6.58
5	**Plastic bags**	0.02	80.21	0.21	5.83

Table 5 Proximate analysis of blended sample

Sr #	Sample	% Moisture	% Volatile matters	% Ash	% Fixed carbon
1	**B 00**	0	36.65	27.93	36.42
2	**B 10**	0	33.42	33.14	33.44
3	**B 20**	0	28.15	35.10	36.75
4	**B 30**	0	27.63	36.90	35.47
5	**B 40**	0	26.43	37.55	36.02
6	**B 50**	0	25.19	38.16	36.65
7	**B 60**	0	24.53	38.00	37.47
8	**B 70**	0	23.10	37.50	39.40
9	**B 80**	0	21.71	38.53	39.76
10	**B 90**	0	19.92	37.93	42.15

2.7 Physical properties of briquette

The briquette is chosen for the assessment of physical properties. The normal greatest thickness of the briquette of coal was calculated quickly after discharge from mold and this was computed as proportion of normal mass to the volume of briquette. The mass was gotten by utilizing advanced weight machine while the volume was ascertained by using dimension of briquette (height and radius). By applying the equation for the volume of cylinder (π R^2 H) the volume of prepared briquette is acquired.

The briquette density was calculated in dry condition subsequent to drying in electric oven is named as relaxed density. It was ascertained just as the proportion of briquette's mass in the wake of drying to its volume. Relaxed density can be characterized as thickness of the briquette got after the briquette has stayed stable. Thickness proportion was figured as the proportion of relaxed density to the maximum density.

Density ratio = Relaxed density/maximum density

In this equation the maximum density was the compressed density of the briquette promptly after discharge from briquette machine.

Figure 3 Briquette diameter and height

Table 6 Briquette physical characteristics

Sr #	Briquette Parameters	Result
1	Height (m)	0.045
2	Diameter (m)	0.06
3	Mass (kg)	O.198
4	Mass of briquette immediately after mould (kg)	0.467
5	Volume (m^3)	0.000127
6	Maximum density (kg/m^3)	3677.16
7	Relaxed density (kg/m^3)	1559.05
8	Density ratio	0.423
9	Colour	Black
10	Texture	Rough
11	Shape	Cylindrical

3. Result and Discussion

3.1 Proximate and composition analysis

Table 1 describes composition of the formed briquette whereas table 5 represents the proximate analysis of composed briquette. The constant amount of plastic waste is used which is 10 percent in each briquette for good ignition characteristics with 10-20 percent binder in composition. The composition of briquette linearly for coal and biomass. The binder guargum varied randomly. The ash percentage of briquette increases by increases in amount of coal and binder. Though, the utilization of inorganic binder offset for this disadvantage in that it trap the volatiles in briquette giving proficient and low smoke combustion.

3.2 Nitrogen and Sulphur content

Table 3 and figure 4 express the percentage of Sulphur and Nitrogen in composed briquette and expose the lowering N and S. The quantity of nitrogen and Sulphur is lower down as the quantity of biomass is used in less amount. It expressed that during burning the release of nitrogen is zero and a very low amount of Sulphur is released. The small amount of Sulphur and nitrogen in the briquette specifically in B80 and B90 indicates that when combustion the briquette produce no nitrogen and very low Sulphur in environment.

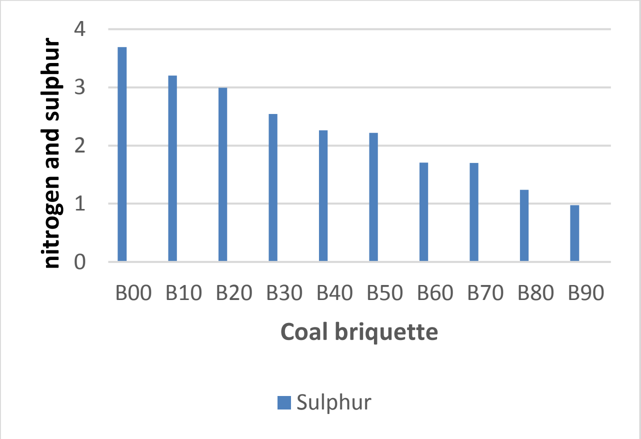

Figure 4 Sulphur and nitrogen content

3.3 Volatile Matters

Table 5 and figure 5 represent that volatile matters diminishes as the amount of biomass present in the briquettes diminishes. In this way, the briquette having higher measure of biomass will ignite quicker contrasted with one with higher level of coal in view of higher level of volatile matters present in biomass.

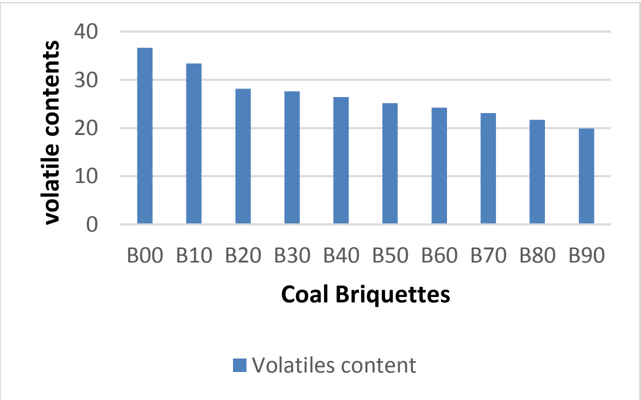

Figure 5 Volatiles content

3.4 Ash and Moisture content

Table 5 and figure 6 represents ash value became lower as the coal quantity is less and due to use of inorganic binder in briquette. The briquette has no moisture content because it was oven dried. Coal contains larger amount of ash as 9.40% related to biomass which is 9.40%. Also, limestone dust which contains minerals (non-combustible) matters will also plays a role to higher the amount of ash in composed briquette. Usually, if ash amount is high than quality of prepared briquette will be low.

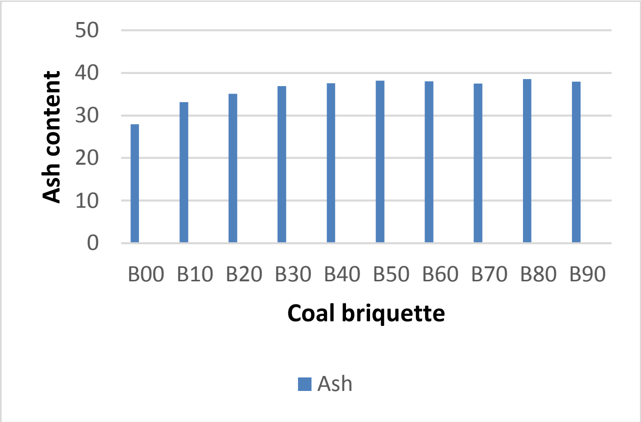

Figure 6 Ash content

3.5 Fixed carbon

Table 5 and figure 7 indicates that fixed carbon have direct relationship with quantity of coal. If coal quantity is increases than fixed carbon in briquette also increased. This was observed because coal is rich in fixed carbon 26.54 percent as shown in table 4.

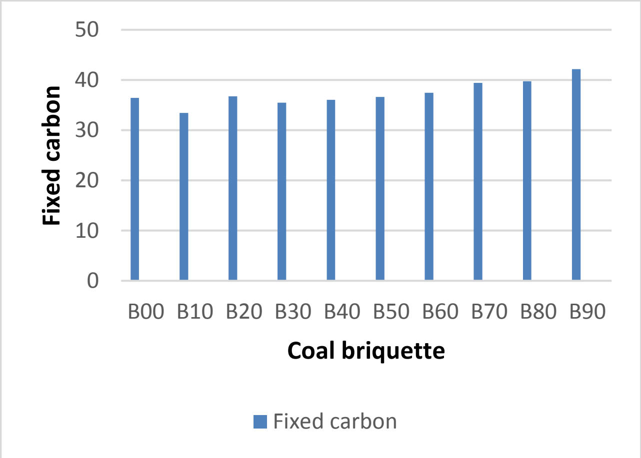

Figure 7 Fixed carbon

4. Conclusion

Produced bio coal briquettes by utilizing carbonized plastic was has observed to be fruitful. The briquette was seen to be great quality since it consumes productively and create less Sulfur. For household cooking briquette sample B10, B2 and B60 to B80 were appeared to be the most effective in term of ash content, heating value and low smoke emission.

5. Acknowledgement

The research was supported by Higher Education Commission under the ASIP program. We thank Higher Education Commission for financial support. Department of Chemical Engineering Mehran UET Jamshoro and National Center of Excellence in Analytical Chemistry, Sindh University Jamshoro, Pakistan who provided insight and expertise that greatly assisted the research.

On personal level I must express my very profound gratitude to my family in particularly my parents for providing me with unfailing support and continuous encouragement throughout the research process. I would like to offer my deep gratitude to Iqra M Akram for her motivational support who has put up with this foray into research. This accomplishment could not have been possible without them.

Reference

[1] H. I. Abdel-Shafy and M. S. M. Mansour, “Solid waste issue: Sources, composition, disposal, recycling, and valorization,” *Egypt. J. Pet.*, 2018.

[2] T. Aized, M. Shahid, A. A. Bhatti, M. Saleem, and G. Anandarajah, “Energy security and renewable energy policy analysis of Pakistan,” *Renew. Sustain. Energy Rev.*, vol. 84, no. March 2017, pp. 155–169, 2018.

[3] K. Ahmed, M. Shahbaz, A. Qasim, and W. Long, “The linkages between deforestation, energy and growth for environmental degradation in Pakistan,” *Ecol. Indic.*, vol. 49, pp. 95–103, 2015.

[4] S. R. Khan and S. R. Khan, “Assessing poverty-deforestation links: Evidence from Swat, Pakistan,” *Ecol. Econ.*, vol. 68, no. 10, pp. 2607–2618, 2009.

[5] M. Ali, A. Marvuglia, Y. Geng, N. Chaudhry, and S. Khokhar, “Emergy based carbon footprinting of household solid waste management scenarios in Pakistan,” *Resour. Conserv. Recycl.*, vol. 131, no. September 2017, pp. 283–296, 2018.

[6] M. S. Korai, R. B. Mahar, and M. A. Uqaili, “The feasibility of municipal solid waste for energy generation and its existing management practices in Pakistan,” *Renew. Sustain. Energy Rev.*, vol. 72, no. January 2016, pp. 338–353, 2017.

[7] P. Prawisudha, T. Namioka, and K. Yoshikawa, “Coal alternative fuel production from municipal solid wastes employing hydrothermal treatment,” *Appl. Energy*, vol. 90, no. 1, pp. 298–304, 2012.

[8] A. Ahmad, Q. J. Liu, S. M. Nizami, A. Mannan, and S. Saeed, “Carbon emission from deforestation, forest degradation and wood harvest in the temperate region of Hindukush Himalaya, Pakistan between 1994 and 2016,” *Land use policy*, vol. 78, no. August, pp. 781–790, 2018.

[9] S. N. A. Tahir, M. Rafique, and A. S. Alaamer, “Biomass fuel burning and its implications: Deforestation and greenhouse gases emissions in Pakistan,” *Environ. Pollut.*, vol. 158, no. 7, pp. 2490–2495, 2010.

[10] F. Zannikos, S. Kalligeros, G. Anastopoulos, and E. Lois, “Converting Biomass and Waste Plastic to Solid Fuel Briquettes,” *J. Renew. Energy*, vol. 2013, pp. 1–9, 2013.

[11] F. I. Nwabue, U. Unah, and E. J. Itumoh, “Production and characterization of smokeless bio-coal briquettes incorporating plastic waste materials,” *Environ. Technol. Innov.*, vol. 8, pp. 233–245, 2017.

[12] M. A. Brand, R. C. Jacinto, R. Antunes, and A. B. da Cunha, “Production of briquettes as a tool to optimize the use of waste from rice cultivation and industrial processing,” *Renew. Energy*, vol. 111, pp. 116–123, 2017.

[13] M. G. Montiano, E. Díaz-Faes, and C. Barriocanal, “Effect of briquette composition and size on the quality of the resulting coke,” *Fuel Process. Technol.*, vol. 148, pp. 155–162, 2016.

[14] J. I. Gug, D. Cacciola, and M. J. Sobkowicz, “Processing and properties of a solid energy fuel from municipal solid waste (MSW) and recycled plastics,” *Waste Manag.*, vol. 35, pp. 283–292, 2015.

[15] M. M. Massaro, S. F. Son, and L. J. Groven, “Mechanical, pyrolysis, and combustion characterization of briquetted coal fines with municipal solid waste plastic (MSW) binders,” *Fuel*, vol. 115, pp. 62–69, 2014.

About the authors

Sanwal Hussain has received his Bachelor of Engineering degree in Petroleum and Natural Gas from Mehran University of Engineering and Technology Jamshoro Sindh Pakistan in 2015. He is a member of SPE International. Currently he is doing his Master of Engineering in Chemical from the Mehran UET Jamshoro. His research interest includes crude oil processing, natural gas processing, coal treatment and simulation.

Dr. Suhail A. Soomro is Prof at Department of Chemical engineering, Mehran University of Engineering and Technology Jamshoro Sindh Pakistan. He has pursued his Bachelor of engineering from Mehran UET Jamshoro Sindh Pakistan in 1989. He completed his MSc in Advanced Chemical engineering from University of Bradford, Bradford U.K in 1992. He awarded his Phd Degree in Chemical engineering from Mehran UET Jamshoro Sindh Pakistan. Prof Suhail awarded Earned British Government Foreign & Commonwealth Office Scholarship 1992 for Doing M Sc in U.K. Earned Gold Medal for securing First Class First Position in Undergraduate Chemical Engineering. His research interest are Drilling fluid system, transmission of heavy oils, Waste Treatment & Management, Bioprocess Engineering & Bioremediation, Polymer Processing & characterization, Clean coal technology, Catalysis & catalyst synthesis and characterization.

Dr. Shaheen Aziz She is professor in Chemical Engineering department at MUET, Jamshoro. She began her career at Chemical engineering department in 1986. She received B.E and M.E in Chemical engineering from MUET. In 2010 she did PhD in Bio-chemical engineering from MUET, Jamshoro. Her research interest are Renewable Energy, Bio fuels, Microbial fuel cell, Fuel cells, Electrical Energy, Sewage Treatment, Environmental Engineering.

Ahsan Ali completed his BE in Petroleum and natural gas from Mehran UET Khairpur campus in 2015. He is currently ME student at Mehran UET Jamshoro in Chemical department. His research interest includes crude oil refining, gas treatment, drilling fluids, kaolin.

Naveed Ali got his Bachelor of Engineering in chemical from Mehran UET Jamshoro in 2015. He is enrolled as ME student in chemical department MUET Jamshoro. His research interests in coal , textile chemicals, kaolin, soil.