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Assessment of Rice Husk Biomass Potential for Power Generation in Pakistan

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Abstract: Rice husk is one of the utmost obtainable feedstock for renewable energy production and can contribute to resolving energy scarcity and environmental problems. Appropriate knowledge of the rice husk's physiochemical properties is essential for the approach of thermochemical conversion systems. The present study delivers data on proximate and ultimate analysis and heating values of rice husk collected from different regions of Sindh, Pakistan. Moisture content was found low ranging between 12.76% to 13.50% (Mean 12.98%), higher volatile matter in the range of 55.77% to 62.88% (Mean 61.19%) and ash particles of 14.50% to 16.48% (Mean 15.20%). The lower concentrations of nitrogen, 0.37% to 1.31%, (Mean 0.70%) and sulfur, 0.02% to 0.19%, (Mean 0.11%) environmentally deal with more appropriate fuel properties. The heating value of rice husk ranges varied from 5,276.33 to 6,237.13 Btu/lb (Mean 5,859.87 Btu/lb). The significant values of the rice husk samples indicated that the locally available renewable resources can be transformed into an extensive amount of energy products at a small level from active conversion techniques. Therefore, rice husk can be deliberated as appropriate fuel for energy generation and can be considered as an environmentally friendly and economically feasible fuel that helps to decline harmful pollutions.

Keywords: Rice husk, physicochemical properties, power generation, environmental friendly.

Introduction

Due to energy disasters and continuous escalation in the rate of fossil fuels, the world's attention is converting to renewable energy sources. Pakistan is facing energy production problem for many years. Maximum of the energy supplies are delivered by petroleum-related products (EIU Report, 2017). Rather than the rice husk being disposed of, using it for energy production can solve the problem of inappropriate discarding methods and resolve the energy shortage. Pakistan is producing millions of tons of biomass per annum (Mirani et al., 2013). Rice is the utmost significant cultivated crop in Pakistan. Its production is about 1.78 million tons (Jaffri, 2018; Mirani et al., 2013) and about 90% remaining is burned in the open air or disposed off into lakes and rivers (Quispe et al., 2017). The yearly production capacity of rice husk is very high and attractive for energy generation, as it has a good usage potential in co-firing schemes (Shahzad, 2015). Rice is cultivated mostly in Punjab and interior provinces of Sindh, Pakistan. The rice husk production in Sindh, Pakistan is approximately 23110 tonnes/yr (World Bank 2016; Iqbal et al., 2018). This husk is gained after splitting the rice grain and it comprises of 20% by weight of rice (Mohiuddin et al., 2016). The remaining can be consumed to meet the country's energy requirement and reduce the environmental effects. One ton of rice paddy produces 220 kg of rice husk and can produce 410–570 kWh of electrical energy (Ali et al., 2016; Yank et al., 2016).

There are limited studies in the literature that have considered rice husk biomass for energy prospective mainly in Pakistan. Nazar et al. (2021) determined that rice husk is a potential fuel in the boiler like other fuels coal, and furnace oil. A boiler produces 370 tons of steam per day with 15 bar pressure at a temperature of 281 °C. The amount of fuel for making 370 tons of steam was changed for rice husk, furnace oil, and coal. It was found that the efficiency of the rice husk, furnace oil, and coal-fired boiler was 87%, 80%, and 64.8%, respectively. This showed that rice husk was an economical energy source that might be efficiently used as boiler fuel. Chokphoemphuna et al. (2019) used the rice husk as fuel in a rectangular fluidized bed combustor. Among the excess air fractions, the maximum burning efficiency of 99.2% is attained at excess air (EA)=60%. Furthermore, burning at excess air (EA)=60% illustrates the lowest emissions of CO, CO_2, O_2, and NOx. Quispe et al. (2017) studied the potential of agriculture residues specifically rice husk. Anshar et al. (2016) found that the usage of rice husk as fuel might reduce the scarcity of electrical energy, reduced the use of fossil fuels and decrease the harmful environmental effects. Mohiuddin et al. (2016) found that it is feasible that if 70% of rice husk remains are consumed for energy, there is a yearly electricity production of 1,328 GWh. The rate per unit energy by rice husk is found at 47.36 cents/kWh as related to 55.22 cents/kWh of electricity produced by coal. Shah et al. (2016) concluded that biomass fuels rice husk and sugarcane bagasse can be deliberated as appropriate fuel for power production and might be delivered as an environmentally friendly fuel for power production. Bhutto et al. (2011) highlighted the matters and tasks in the effective and actual consumption of biomass sources as energy in Pakistan. Energy generation from rice husk mostly depends on its configuration like the proximate and ultimate analysis. Mahar (2010) evaluated various tools for changing agricultural biomass into energy and found it reasonable, environmentally friendly, and economically beneficial. Mirza et al. (2008) studied biomass energy consumption in Pakistan also discoursed the diverse scopes of generating electricity through biomass. The biomass is an unpolluted and economical fuel selection with marvelous potential for Pakistan. Numerous thermochemical conversion systems like CFB boilers and gasifier have been verified, considered, and used for the production of energy from numerous biomass resources (Sharma et al., 2014; Lee et al., 2019; Tareen et al., 2020). Effectual consumption of biomass and waste to bio-energy can also add in the direction of resolving energy scarcity and decreasing dependence on fossil fuels assets (Danish et al., 2015). The quality of biomass is significant on burning mainly in various phases of the power plant process. The installed capacity and the biomass quality are two important factors in the rate of electricity production. For effectual consumption, a complete understanding of various properties of the locally available rice husk, biomass is necessary for appropriate design and modeling of the power plant.

The study objective was to examine the physico chemical characteristics of rice husk attained from various parts of Sindh. These included proximate and ultimate analysis and heating values. This study work will provide basis for future research on the potential of rice husk biomass for power production at a small level that might be suitable for a single district or village to fulfill the local energy requirement. This study will also increase the attention of consuming agricultural residual rice husk for beneficial products with numerous public and environmentally friendly benefits.

Materials and Methods

Samples of rice husk were attained from six different parts of Sindh, Pakistan. These samples around 5 kg, were taken, retained in polyethylene bags, and conveyed to the research laboratory for physiochemical examination. Sample collection, preparation, and analytical techniques were accompanied by rendering to the ASTM methods. For air-dry loss (ADL), the samples were determined in an air-drying oven (ASTM D-3302) as well as crumpled, ground, and pulverized to 60 meshes (ASTM D-2013). For characterization and average results, every residue sample was investigated and reported. The examination figures of As-determined (Ad) basis were transformed into As-received (AR) basis (ASTM D-3180).

The standard examination technique for proximate analysis used ASTM methods (D-3172-5). The moisture content was assessed in a drying oven at 105-110 ^{o}C temperature by the mass loss of the rice husk sample. For volatile matters, the mass loss was noted after retaining the sample in a muffle furnace at 900-950 ^{o}C for 10 minutes.

The elemental configurations of the rice husk were found by ultimate analysis applying ASTM method (D-3176, D-5373). Ultimate analysis was used to evaluate the carbon, hydrogen, nitrogen, and sulfur substances of the rice husk samples. Elementary CHNS Vario micro cube analyzer is used for the analysis of carbon, hydrogen, nitrogen, and sulfur contents of the dried rice husk samples. The apparatus is built upon Thermal Conductivity Detector (TCD) and Gas Chromato graphic Column. The analyzer is fully computer compatible, fitted with an auto-sampler. The rice husk samples were weighed into tin foil dishes with the additive in duplicate. The heating/calorific value of the rice husk samples was determined by ASTM (D2015) bomb calorimeter.

Results and Discussion

Proximate Analysis

The moisture content was found between 12.76% to 13.50% (Mean 12.98%). The moisture content contributes a vital part to the assortment of effective thermal transformation tools (Table 1, Fig. 1). Rice husk moisture content significantly affects its value as a fuel resource. Therefore, a dry fuel substantial is favored for burning (Emérita et al., 2020). Rice husk has comparatively higher volatile matter content that varies between 55.77% to 62.88% (Mean 61.19%). The volatile matter is a vital part of the fuels since it describes the predictable pollution of the product gas in the thermochemical transformation system. The fuel volatile content has a prodigious effect on the burning sequence and the structure of the burning compartment (Quispe et al., 2017). Rice husk has a lower fixed carbon which varies from 9.35% to 14.75% (Mean 10.63%). Rice husk has a comparatively higher ash content. The ash content ranged from 14.50% to 16.48% (Mean 15.20%), which are mostly silica as its configuration is around 90-95% in ash (Danish et al., 2015). Ash of rice husk is useful in many industries like rain force brick, cement manufacturing, etc.

Table 1 Rice husk proximate analysis as received basis (AR)

Variable	**Rice Husk Proximate Analysis As Received (AR) Basis (%)**				**Heating Value (Btu/lb)**
	Moisture	**Ash**	**Volatile Matter**	**Fixed Carbon**	
Sample 1	12.92	14.75	62.88	9.45	6237.13
Sample 2	12.76	14.69	61.98	10.57	5768.92
Sample 3	12.90	14.50	62.74	9.86	6164.37
Sample 4	13.09	14.81	62.31	9.79	6055.46
Sample 5	13.50	15.98	55.77	14.75	5276.33
Sample 6	12.77	16.48	61.40	9.35	5657.02
Min	**12.76**	**14.50**	**55.77**	**9.35**	**5276.33**
Max	**13.50**	**16.48**	**62.88**	**14.75**	**6237.13**
Mean	**12.98**	**15.20**	**61.19**	**10.63**	**5859.87**

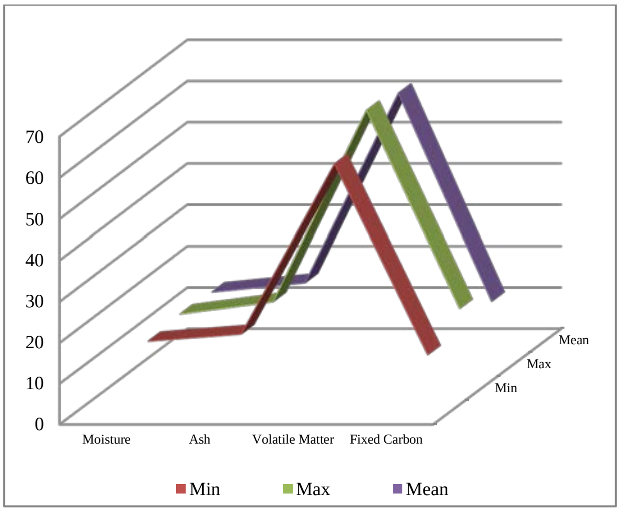

Fig. 1 Samples (1-6) Min, Max and mean proximate analysis of the rice husk (%)

Table 2 Rice husk ultimate analysis as received basis (AR)

Rice Husk Ultimate Analysis As Received (AR) Basis (%)				
Variable	**Carbon**	**Hydrogen**	**Nitrogen**	**Sulfur**
Sample 1	35.54	5.56	0.53	0.17
Sample 2	34.23	5.78	1.31	0.19
Sample 3	41.35	5.38	0.37	0.07
Sample 4	41.79	5.85	0.43	0.02
Sample 5	32.24	5.71	0.67	0.15
Sample 6	36.88	5.45	0.60	0.08
Min	**32.24**	**5.38**	**0.37**	**0.02**
Max	**41.79**	**5.85**	**1.31**	**0.19**
Mean	**37.02**	**5.62**	**0.70**	**0.11**

Heating Value

The heating value of the rice husk ranged from 5,276.33 to 6,237.13 Btu/lb (Mean 5,859.87 Btu/lb). The heating value is a significant thermal property that delivers higher assessments of the fuel. The significant rice husk samples heating value indicated that it can be transformed to an extensive quantity of energy products by using active transformation tools (Danish et al., 2015).

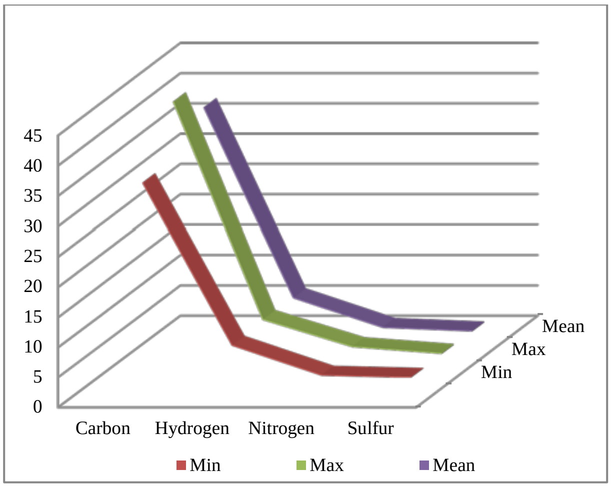

Fig 2 Samples (1-6) Min, Max and Mean ultimate analysis of the rice husk (%).

Ultimate Analysis

The ultimate study is mainly significant in assessing the fuel in expressions of its pollution potential. The important basic elements of rice husk are carbon, nitrogen, hydrogen, and sulfur. These components are significant in evaluating the suitability of the fuel and also deliver statistics on the production of undesirable materials through the combustion process relating to the pollution problems (Cláudio et al., 2019). The values of the ultimate analysis are shown in Table and Figure 2. The percent portion of carbon varied from 32.24% to 41.79% (Mean 37.02%); and hydrogen varied from 5.38% to 5.85% (Mean 5.62%). In rice husk samples, nitrogen and sulfur percentages were very low ranging from 0.37% to 1.31% (Mean 0.70%) and 0.02% to 0.19% (Mean 0.11%), respectively. The small percentages of nitrogen and sulfur offer environ mentally more appropriate fuel possessions.

Conclusion

The study was concluded to define the physicochemical characteristics of rice husk from different regions of Sindh. Determine their potential to be used in the small thermal transformation process for energy production. Rice husk contains low moisture, higher volatile matter, and ash content. The lower percentages of nitrogen and sulfur deal better with environmentally appropriate fuel properties. The physiochemical analysis and heating value indicated that these locally accessible renewable resources can be transformed into an extensive quantity of energy products from active conversion techniques like different types of fluidized bed technology. Therefore, rice husk can be deliberated as appropriate fuel for energy generation to reduce the energy shortage and can be considered as an environmentally friendly fuel for power production.

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