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Blending of biomass fuel as a renewable and coal in co-combustion for environmental friendly power generation

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Abstract: **Because coal contains sulfur, NOx, and SOx emissions during the burning of fossil fuels can cause corrosion and other environmental issues including acid rain. Concerning this, research has been done to determine whether biomass can lower levels of nitrogen oxide (NOx) and sulphur oxide (SOx). The current research focuses on the effects of burning coal and biomass together to provide environmentally friendly electricity. The combustion process of coal-biomass blends and their emissions have been studied using a variety of coal-to-biomass ratios. Four different biomass were mixed with coal in different ratios, such as 80/10, 70/20 and 60/30, and 50/40. The least emissions were noted during the co-combustion of coal at a ratio of LC80 percent + banana tree waste (BTW) 20 percent, while the maximum emissions were found at 100% lignite coal (LC). After the blending of coal and biomass characterization was done by using thermogravimetric analysis (TGA). It will be simple to choose to utilize biomass with coal if it results in less CO2, NOx, and SOx emissions throughout the co-combustion process. The researchers came to the final conclusion that the combination of biomass and lignite coal may be used to address environmental harm and promote sustainable energy production. In order to reduce pollution emissions, biomass will require less energy to burn than coal.**

Keywords **– biofuel, eco-friendly combustion, co-combustion, lignite coal, SOx emission, NOx emission**

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I. INTRODUCTION

In the recent past, challenges have arisen concerning energy problems and global warming. It is due to the pollution, abbreviated as SOx, HOx, $CO_{X,}$ and NOx respectively, of sulfur oxides, carbon oxides, and nitrogen oxides. Which causes the depletion of the ozone layer, acid rain, and environmental pollution. Various technologies are in place to reduce these dangerous contaminants[1]. Co-firing will also reduce the cost of fuel, reducing waste. Among these pollutants are sulphur oxides (SOx) and nitrogen oxides (NOx), which cause ozone depletion and acid rain, respectively. Additionally, greenhouse gas emissions (CO_2, CH_4, etc.) are evolving into a global threat. Several methods have been proposed to reduce the gaseous SOx, NOx, and CO_2 emissions from the burning of fossil fuels and to reduce the costs associated with these techniques of mitigation with a high percentage with lignite coal to a ratio of 80:20 respectively, the biomass content of rice husk and bamboo creates less pollution [2], [3]. Biomass with coal co-combustion has proven to become an affordable, effective, environmentally friendly, and sustainable alternative for renewable energy that meets Sulphur oxide, carbon oxide, and nitrogen oxide reduction requirements [4], [5]. The consumption of biomass is based on producing low concentrations of

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CO_2 during combustion. Besides, in a coal-fired power generation system, for example, in a case where coal is co-fired alone in the power generation system, it helps to minimize CO_2 emissions. It is also understood that the efficacy of the method is reduced. An effective way to minimize net greenhouse gas emissions is to use biomass in combustion processes, e.g. CO_2 from the Atmosphere [2]. Alcohol production processes, such as direct combustion, pyrolysis, or fermentation, have made use of biomass as an energy source. Until recently, many studies have been performed on co-firing of energy production blends of coal/biomass [6], [7]. Cattle manure, sawdust, sewage sludge, wood chips, straw, and fuels obtained from waste are some typical biomass fuels used in co-firing experiments. For a number of reasons, renewable resources are known to be environmentally benign. The combustion of biomass fuel does not result in a net increase in CO_2. Additionally, blending coal and biomass fuels will reduce the CO_2 emissions from petroleum. Co-firing, as opposed to landfilling biomass leftovers, provides extra greenhouse gas reduction by reducing CH_4 release (sewage) (Sludge, manure, and so on). The net emissions of SOx can also be decreased since some of the SOx emitted during combustion is also removed by alkaline ash from biomass. Furthermore, in many cases, the nitrogen content of biomass is much lower than that of coal and is mostly converted to ammonia during combustion. Co-firing can also result in lower levels of NOx as well. Mixing can also lead to lower-cost oils being used, with the price of petrol being reduced. In many works, the impact of biomass addition on gas emissions is addressed [6], [8], [9], [10]. A near-term, sustainable, low-cost, low-risk, recyclable, renewable energy source that intends to lower net CO_2 emissions, lower emissions of SOx and, occasionally, NOx, and provide other societal advantages is the combustion of biomass-Lignite coal mixture [8]. Fluidized bed circulation systems have shown success in burning biomass, particularly rice husk systems, bubbling fluidized bed, and bubbling among the combustion technologies [11], [12]. Due to the CO_2 neutrality and low Sulphur content of burning renewable cultured biomass, co-firing biomass with coal has lately increased in order to mitigate the harmful environmental effects of coal. urban solid trash removal and energy recovery from toxic waste [5]. Boost the case for the use of biomass by fossil fuel co-firing. In addition to reducing CO_2, A tried-and-true method for lowering SOx and NOx emissions from coal combustion is co-fired coal biofuels [13]. Co-combustion of coal and biomass for energy production is becoming more popular on a global scale [14]. Research has been done to determine how biomass might impact SO_2 emissions. Because electricity demand has increased significantly in developing countries, fossil fuels are frequently used to meet that demand. Biomass and waste can thus be used as a substitute for fossil fuels in the production of electricity. Renewable energy will significantly reduce greenhouse emissions because it is less risky and easier for power plants to meet energy demand [4], [13], [15]. Utility boilers can successfully co-fire up to 20% biomass and coal. Biomass co-firing of coal has been carried out as follows, according to the findings of comprehensive applications: 1) Improved boiler performance; 2) cheaper fuel; and 3) reduced NOx and fossil CO_2 emissions [6]. Co-combustion of coal and biomass holds the potential to minimize anaerobic releases of CH_4, NH_3, H_2S, amides, volatile organic acids, mercaptans, esters, and other compounds, as well as net emissions of CO_2, SOx, and occasionally NOx [16], [17] [19]. Ability to accommodate the nature of the thermal actions of biomass materials is one of the requirements for the implementation of co-firing, as well as the required modifications [22]. As a result, reaction kinetics and thermal properties are significant. The conversion of coal biomass into energy using thermochemical reactions to improve the method's performance. As a consequence, reaction kinetics and thermal properties are important considerations. The use of thermo-chemical reactions to convert coal biomass into energy to boost the method's efficiency [18]. One of the most effective ways to produce electricity is by co-combustion[20]. There are a few solutions available in this situation [21]. Co-combustion was bolstered by tougher environmental controls and the problem of fossil fuel depletion[23]. The use of thermogravimetric analysis (TGA) during solid combustion gasoline allows for the investigation of thermal accidents to be completed quickly[24][25]. When coal is co-fired with cow dung and manure, the mixing ratio affects gaseous pollutant emissions [26].

II. MATERIALS AND METHODS

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2.1 Materials

At Mehran University of Engineering and Technology's chemical engineering department, research was carried out in the particle technology lab and the environmental chemistry lab. Using tree leaves, cow dung, banana tree waste coal, tree leaves, and biomass sample, the calibrated 300-micron meter sieve scale of brown coal gathered for co-combustion with 300-micron particle size was crushed and ground to make homogeneous particle size. Various blending ratios have been created to analyze the optimized blending ratio. Condition for combustor burning of fluidized beds. When the sample was burned at 300 C^0, the emission of SO_x and NOx was measured using a stack gas analyzer. Co-combustion took place using the laboratory furnace and the emission of gases tracked by the emission analyzer.

2.2 Methods

In the methodology used in the block diagram, the biomass sample was collected and crushed, and grind in the laboratory by using a jaw crusher as well as a grinder. Different biomass and coal were blended by helping of a laboratory-scale blender. The weight of both samples was carried out by utilizing the weight machine in the department of chemical engineering. Results from the co-combustion of coal and biomass were evaluated. Different emissions were analyzed with help of an analyzer.

Fig. 1. Methodology for carrying out research

The successive steps for co-combustion of cow dung manure and lignite coal are shown in table 1 and figure.2

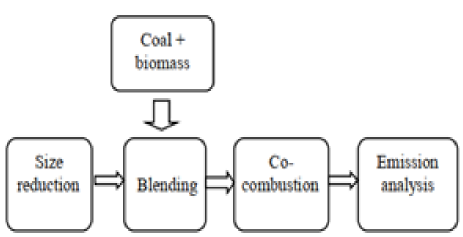

Table. 1: Chemical Characteristic of Lignite Coal and Cow Dung Manure

Parameter	Average value	
	Cow dung manure	Lignite coal
Carbon	36.028	57.651
Hydrogen	5.671	5.63
Nitrogen	0.358	0.213
Sulfur	0.139	6.345

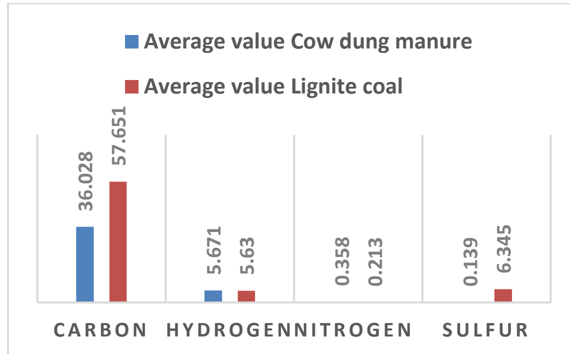

Fig. 2. Parameter of cow dung manure and lignite coal

2.3 Biomass

Biomass is now involved in its availability and environmentally sustainable solution. Biomass consists mainly of organic matter that is naturally created by photosynthesis and also by artificial photosynthesis. Different biomass sources are given in the definition figure. 2.

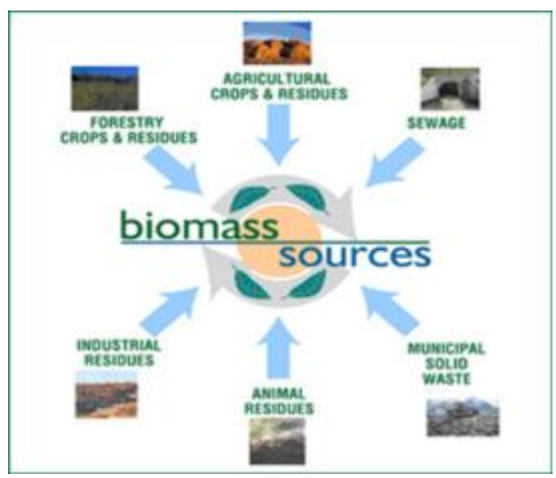

Fig. 3. Different Sources of Biomass

2.4 Banana tree waste

Banana tree waste is also grown in many parts of the world and some portion of banana tree waste is also

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produced after the growth time. Therefore, to minimize the essential needs of the environment, it is important to use them. However Pakistan has several areas covered by banana tree waste, so it is important to use it in a good way to decrease the amount of environmental waste and also to be suitable for the climate. It can be used for co-combustion with coal for banana tree waste to minimize pollution and increase the amount of energy as well.

Fig. 4. Banana tree waste

2.5 Cow dung manure

Cow dung waste being present in enormous amounts in the world because it provides advantages in terms of burning. As in various regions of the world, manure from cow dung becomes directly used for burning practices. But as far as is rising towards the latest technology co-combustion introduced due to its potential. Dung from the cow for biogas production, manure also has advantages.

Fig. 5. Cow dung waste

2.6 Tree leaves

There are several benefits of tree leaves to environmental emissions. The tree leaves were also used for co-combustion and combustion for several distinct prospects. As we know, since this researcher created the techniques, each part of the world consists primarily of tree leaves.

Fig. 6. Tree leaves

III. RESULTS AND DISCUSSION

Co-combustion has several benefits over Sox and Nox, and it has gotten a lot of publicity because low-value waste can be used in the energy sector while still benefiting the atmosphere. When there's a lot of biomass around. The amount of Nox and Sox in the flue gas was found to be very low during combustion. To investigate the low emission ratio in terms of environmental emissions, different blending ratios were used. As a result, a separate coal-to-biomass mix is used to reduce emissions. Table 2 and figure 6 provide information on the heating value of lignite coal and banana tree waste as well as their blending ratios. When compared to other blending ratios, which have a heating value of about 744454.6 Btu/lb, the 70/20 ratio for coal and banana tree waste has the highest heating value.

Table. 2: The heating value of different coal and banana tree waste blends

Sample	Heating value (Btu/lb)
LC	630539.9
BTW	709612
LC80%+BTW10 %	697342.6
LC70%+BTW20 %	744454.6

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LC60%+BTW30 %	827016.2
LC50%+BTW40 %	642423.2

Table. 3: Emission analysis of coal and banana tree waste blends

Sample	CO	CO_2	NO_X	SO_X
Lignite Coal	901.83	2190	30.63	325
BTW	1510	1633	64.66	66.67
LC80%+BTW 10%	1136.16	3105	45.83	9.83
LC70%+BTW 20%	12475	2515	42.66	305
LC60%+BTW 30%	1449.2	3255	44	18
LC50%+BTW 40%	1644	2970	55.5	47.66

Effect of banana tree waste over coal blending ratio of emissions

Co-combustion of coal and biomass presence had many advantages related to a good environment and production of energy. Different ratios of blending have a lot of advantages like energy as well as an environmental condition. In figure.7, it was shown that 70:20 for coal and biomass banana tree waste gives good energy production.

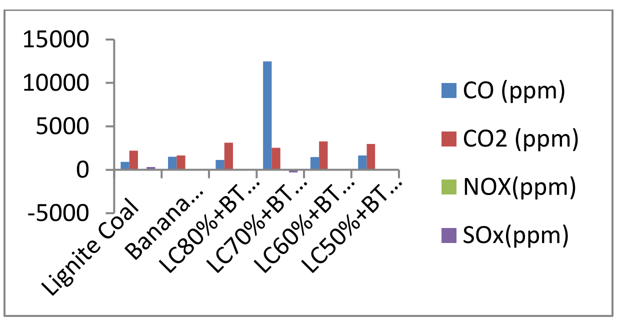

Fig. 7. Effect of coal as well as banana tree waste on emission

Co-Combustion of coal, biomass and their blends

Co-combustion is a process where two or more two fuels was combusted in the same plant for energy production. Co-combustion of coal and biomass as well as the temperature is shown in the diagram. For Co-combustion electrical muffle furnace was used to carry out the process, Results were analyzed using a stack gas analyzer**,** the methodology used for co-combustion is shown in the fig. 8.

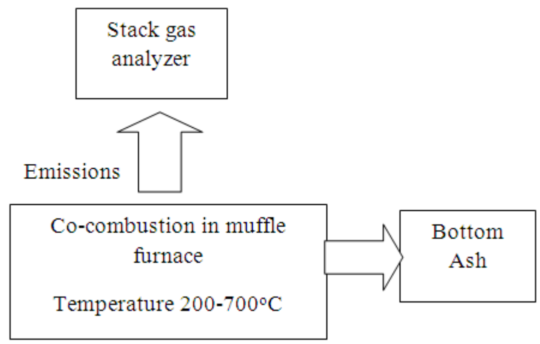

Fig. 8**.** Co-combustion of Coal and Biomass

CHNS analysis of coal, biomass, and their blends

The CHNS analyzer was used to examine carbon, hydrogen, nitrogen, and sulfur. The results of the CHNS have given in Table.3, which is shown below the values. The results of the biomass have a low sulfur content but a high carbon content. Percentages of carbon, hydrogen, nitrogen, and sulfur are included in the CHNS study. Different elemental basis analyses were performed in the figure because we can't forecast and it properly if we don't know the elemental analysis. Cow dung manure has a gross nitrogen percentage of 0.364 percent and minimum nitrogen of 0 percent Lignite Coal.

Table. 4: Result of CHNS Analysis of L.C and Biomass (TL, CDM, BTW)

No	Sample Name	C %	H%	N%	S%
1	Lignite coal (LC)	58.662	4.640	0.000	5.369
2	Cow dung manure (CDM)	37.029	4.681	0.364	0.149

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3	Banana tree waste (BTW)	35.953	4.726	0.000	0.309
4	Tree leaves (TL)	52.210	5.266	0.000	0.071

2.10 Thermogravimetric analysis of lignite coal

The purpose of the TGA analyzer was to determine the moisture content. The temperature was raised to 108.15^{0}C and kept for 15.78 minutes for figure 9. The moisture content was found to be 12.21%. The temperature for the volatile matter was set at 949.03^{0}C for 39.14 minutes. The volume of volatile matter in the coal was found to be 36.83 percent of the total mass. The temperature was held at 950^{0}C for 45 minutes for fixed carbon, and the volume was found to be 35.73 percent. The residue was ash, which was discovered through the measurement of volatile matter. The total amount of fixed carbon was found to be 15.21%.

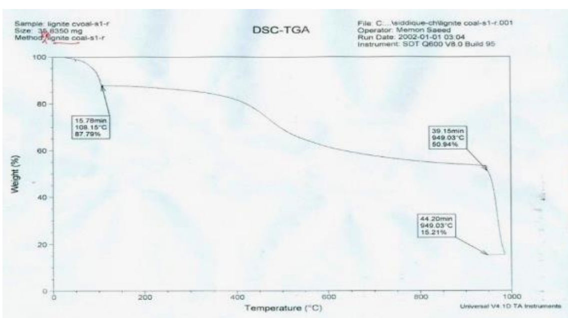

Fig.9. TGA analysis of lignite coal

Table. 5: Heating values of Coal, Biomass and Their Blends

Sample Name	Value of Heating (BTU/lb)
Lignite coal(LC)	730439.9
Tree Leaves(TL)	794740.4
Banana tree waste(BTW)	809712
Cow dung manure (CDM)	713800
Lignite coal 80% + Tree leaves 10%	700643.3
Lignite coal 70% + Tree leaves 20%	703483.7
Lignite coal 60% + Tree leaves 30%	812468.4
Lignite coal 50% + Tree leaves 40%	772025.3
Lignite coal 80%+Banana tree waste 10%	796342.6
Lignite coal 70%+Banana tree waste 20%	854454.6
Lignite coal60%+Banana tree waste 30%	827016.2
Lignite coal 50%+Banana tree waste 40%	633423.2
Lignite coal 80%+Banana tree waste 10%	893951.9
Lignite coal 70%+Banana tree waste 20%	536007.6
Lignite coal 60%+Banana tree waste 30%	522179.1
Lignite coal 50%+Cow dung manure 40%	784558.3

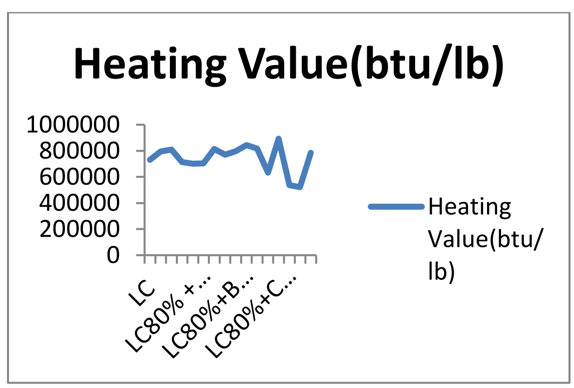

Fig. 10. The heating value of different biomass and lignite coal blends

IV. CONCLUSION

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Co-combustion has had many benefits over fossil fuel combustion due to reductions in the percentage of biomass and coal blend has an advantage regarding emissions of greenhouse gases compare to pure coal. For co-combustion with Pakistani low-rank coal, four biomasses were used. Utilizing a co-combustion process, the addition of biomass had an advantage over the emission of NOx and SOx. So, 60% lignite coal and 30% cow dung manure ratio have a minimum amount of emission was observed. It means cow dung manure addition gave the best result. Regarding energy production, 80% lignite coal+10% cow dung manure gives more energy production about 892951.9 BTU/lb. The addition of banana tree waste had a positive effect on coal co-combustion, but there was no sufficient impact on pollution as far as other biomass was concerned. At 80 percent lignite coal and 20 percent banana tree waste, the minimum SO_2 emission was observed. Further, the blended sample were characterized by using TGA. Additionally, adding biomass to lignite coal for energy production can make the process more sustainable.

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