ISSN-1996-918X

Pak. J. Anal. Environ. Chem. Vol. 17, No. 1 (2016) 18 – 22

doi: 10.21743/pjaec/2016.06.003

Comparative Study of Coal and Biomass Co-Combustion with Coal Burning Separately Through Emissions Analysis

Mohammad Siddique*[1], Suhail Ahmed Soomro[2], Aziza Aftab[3], Zahid Naeem Qaisrani[1], Abdul Sattar Jatoi[4], Asadullah[1], Ghulamullah Khan[1] and Ehsanullah Kakar[5]

[1]*Chemical Engineering Department, BUITEMS, Quetta, Pakistan.*
[2]*Institute of Petroleum and Natural Gas Engineering, MUET, Jamshoro, Sindh, Pakistan.*
[3]*Department of Chemical Engineering, MUET, Jamshoro, Pakistan.*
[4]*Chemical Engineering Department, MUET, Jamshoro, Pakistan.*
[5]*Faculty of Civil Engineering, BUITEMS, Quetta, Pakistan.*
*Corresponding Author Email: siddiqnasar786@gmail.com
Received 01 February 2016, Revised 23 June 2016, Accepted 27 June 2016

Abstract

Appropriate eco-friendly methods to mitigate the problem of emissions from combustion of fossil fuel are highly demanded. The current study was focused on the effect of using coal & coal-biomass co-combustion on the gaseous emissions. Different biomass' were used along with coal. The coal used was lignite coal and the biomass' were tree waste, cow dung and banana tree leaves. Various ratios of coal and biomass were used to investigate the combustion behavior of coal-biomass blends and their emissions. The study revealed that the ratio of 80:20 of coal (lignite)-cow dung and 100% banana tree leaves emits less emissions of CO, CO_2, NOx and SO_2 as compared to 100% coal. Maximum amount of CO emissions were 1510.5 ppm for banana tree waste and minimum amount obtained for lakhra coal and cow dung manure (70:30) of 684.667 ppm. Maximum percentage of SO_2 (345.33 ppm) was released from blend of lakhra coal and tree leaves (90:10) and minimum amount of SO_2 present in samples is in lakhra coal-banana tree waste (80:20). The maximum amount of NO obtained for banana tree waste were 68 ppm whereas maximum amount of NOx was liberated from lakhra coal-tree leaves (60:40) and minimum amount from cow dung manure (30.83 ppm). The study concludes that utilization of biomass with coal could make remedial action against environment pollution.

Keywords: Lignite coal; Co-combustion; Biomass; Emission; Environmental friendly.

Introduction

Utilization of biomass in combustion processes is a promising way to reduce net greenhouse gas emissions, e.g. CO_2, to atmosphere [1]. The use of biomass as an energy source has been utilized by techniques, such as, direct combustion, pyrolysis or fermentation for alcohol production. Until recently, there have been number of studies concerning the co-firing of coal/biomass blends for energy generation [2]. Some typical biomass fuels in co-firing studies are cattle manure, sawdust, sewage sludge, wood chips, straw and refuse-derived fuels. Biomass fuels are considered environmentally friendly for several reasons. There is no net increase in CO_2 because of burning biomass fuel. Therefore, blending of coal with biomass fuels can reduce fossil-based CO_2 emissions. Co-firing brings additional greenhouse gas mitigation by reducing CH_4 release as compared to landfilled biomass residues (sewage sludge, manure, etc.). The alkaline ash from biomass also captures some of the SO_2 produced during combustion and therefore the net SO_2 emissions can also be reduced. In addition, the nitrogen content in biomass in many cases is much lower than in coals and is mainly converted to ammonia during combustion. Hence, co-firing can also result in lower NO_x levels. Blending can also result in the utilization of less-expensive fuels with a reduction in fuel costs. There are several works dealing with the effect of biomass addition on the gas emissions [3–15]. The current study is focused on the co-combustion of lignite coal and biomass in different ratios of both the components to optimize the process. The study was further extended to study the impacts of different ratios of lignite coal and biomass on the emissions.

Materials and Methods

Materials

For co-combustion coal and biomass was used. The coal used were lignite coal (LC) & the biomass used were tree leaves (TL), cow dung manure (CDM) and banana tree leaves (BTL). The coal-biomass were used in 90:10, 80:20, 70:30 and 60:40 ratio. Lignite coal was collected from Lakhra coal field. Three type of biomass were collected from different area of district Hyderabad, Pakistan.

Methods

Samples were crushed by black jaw crusher and hammer mill to increase surface area, because during co-combustion particle size also play an important role. The samples were ground in water cooled disc pulverizer to reduce to desired size. The samples were then sieved by using sieve shaker to characterize the particle size. For this work, 300 micron mesh size were used for coal and biomass co-combustion. For co-combustion electric muffle furnace (1300^{O}C) was used. The emission of gases were measured by emission analyzer. (Fig. 1) shows the successive steps for co-combustion for analysis of different gases.

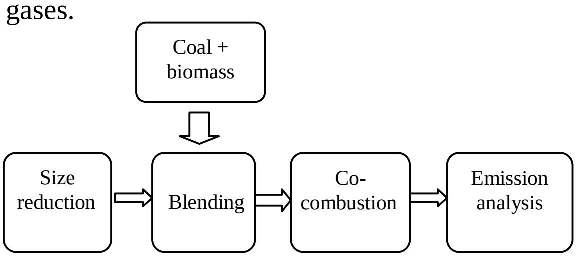


Figure 1. **Co-combustion of coal and biomass**

To make different ratio of coal and biomass blends laboratory scale blender and electronic balance were used.

Results and Discussion

Effect of lignite coal and cow dung manure blend on emissions

During co-combustion, the blending ratio of biomass and coal had a significant impact on emission of gases. In order to optimize blending ratio of coal and biomass, different blending ratios of lignite coal and cow dung manure were used to investigate the minimum ratio that generates less gaseous emissions. The ratio that have been used were 90:10, 80:20, 70:30 and 60:40 for lignite coal and cow dung manure. Fig. 2a and b highlight the emission of CO_2 and CO, where maximum emission of CO_2 was observed with the use lignite coal 70% with 30% cow dung manure. Minimum emission were observed with the use of 100% cow dung manure. Fig. 2c and d show that when increasing biomass percentage with coal, there is decrease in emission of SO_2 due to capturing of sulfur by biomass. Similarly, emission of NO_2 showed the similar trend. From the results, it is revealed that addition of biomass reduces the greenhouse gas emissions as shown in Fig. 2.

Effect of blending ratio of lignite coal and banana tree leaves on emissions

In this set of experiments, lignite coal and banana tree leaves were blended in different ratios to investigate and optimize the process of co-combustion with respect to gaseous emissions. Fig. 3a and b shows that CO and CO_2 emissions using different blending ratio of coal and banana tree leaves. The minimum emission were observed at the blending ratio of lignite coal and banana tree leaves (90:0), whereas maximum emissions were found at 80:20. It revealed that with addition of higher percentage of banana tree leaves, emissions were reduced. In Fig. 2c and d results of NOx and SO_2 were compared with co-combustion of coal and banana tree leaves. Minimum emission of SO_2 was observed with addition of more biomass and maximum emission of SO_2 were observed, when coal was separately burned.

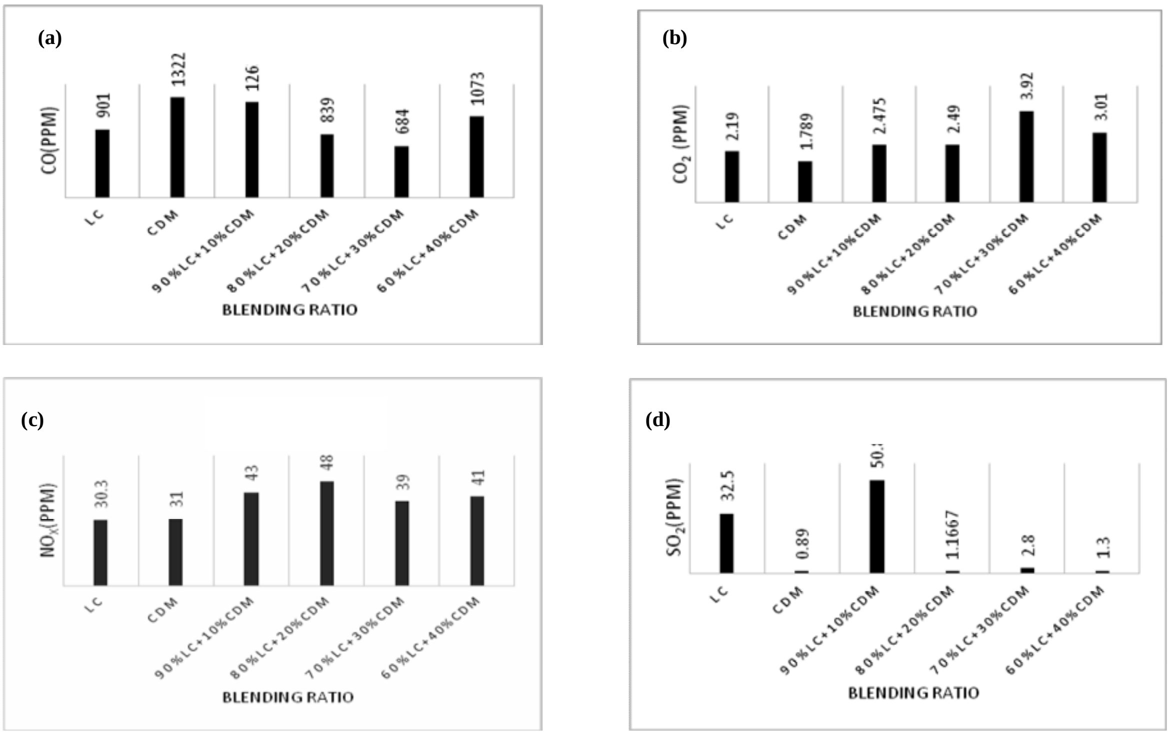


Figure 2. **Effect of different blending ratio of coal and cow dung manure on (a) CO, (b) CO_2,(c) NO_x and (d) SO_2**

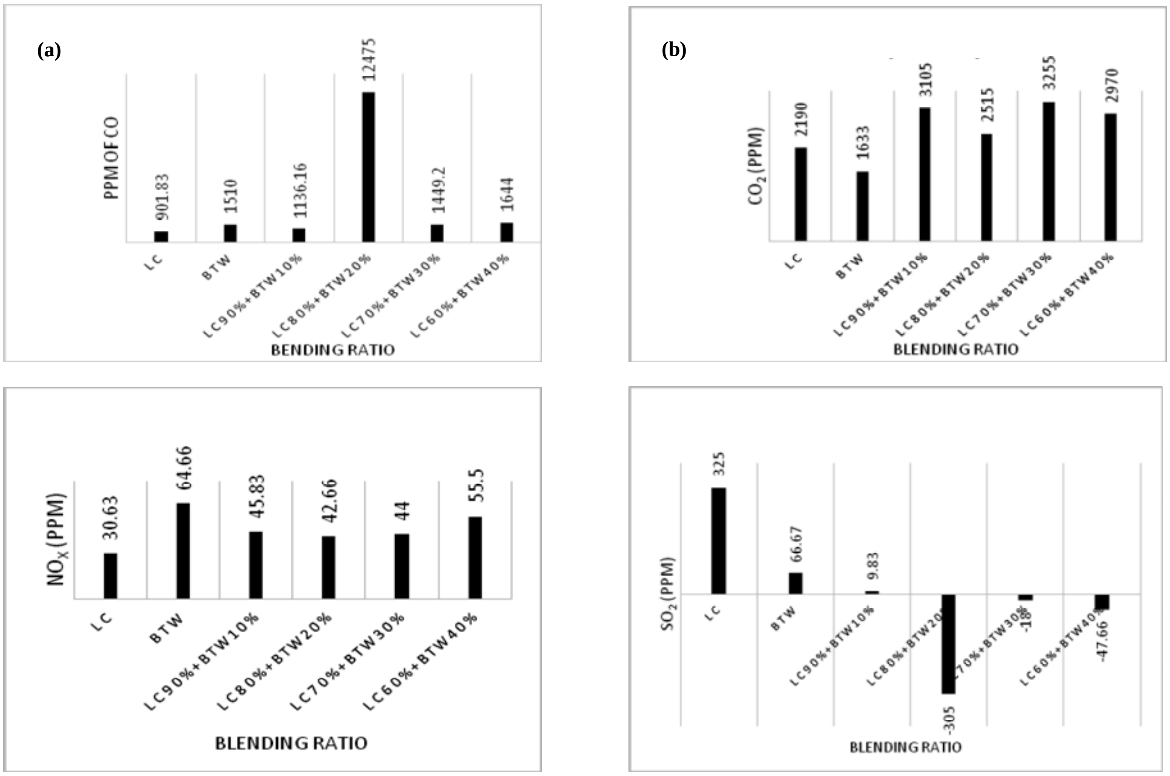
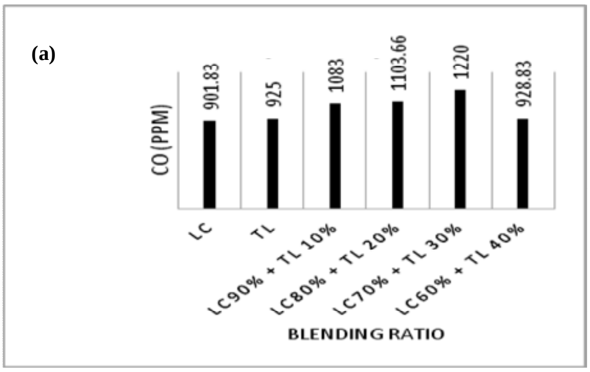
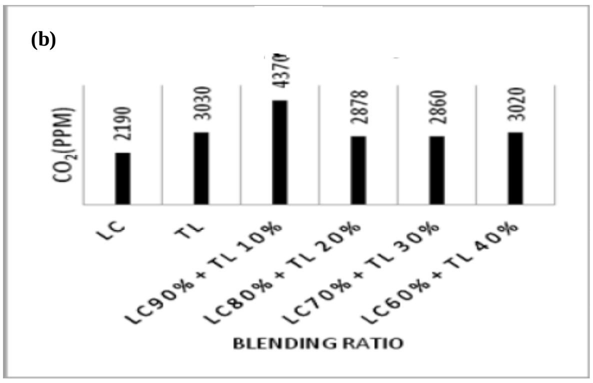


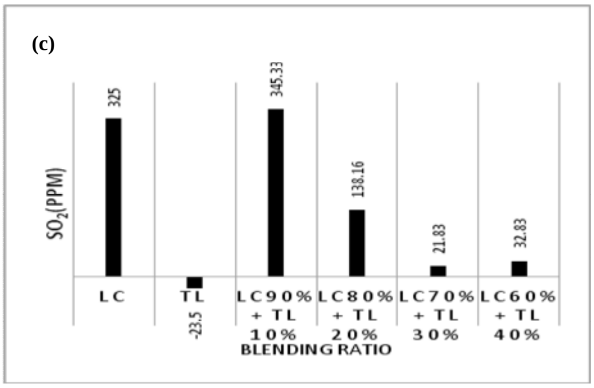
Figure 3. **Effect of different blending ratio of coal and banana tree waste on (a) CO, (b) CO_2, (c) NO_x and (d) SO_2**

Effect of blending ratio of lignite coal and tree leaves on emissions

Another biomass that were used in the research was tree leaves with lignite coal in different ratios to investigate the potential use of biomass that contribute in reduction of environmental pollution and energy production. In Fig. 2, different blends of lignite coal and tree leaves were used for identification of optimum results of co-combustion that generates less emissions. The maximum emission of CO and CO_2 were observed at the blending ratio of lignite coal and tree leaves (70:30), whereas higher emissions were observed at 90:10. The emission of NOx, as a result of addition of biomass have not shown satisfactory results with reference to emissions t due to nitrogenous compound present in tree leaves. When we focus SO_2 emissions, addition of biomass gave a minimum amount of emission in terms of SO_2.







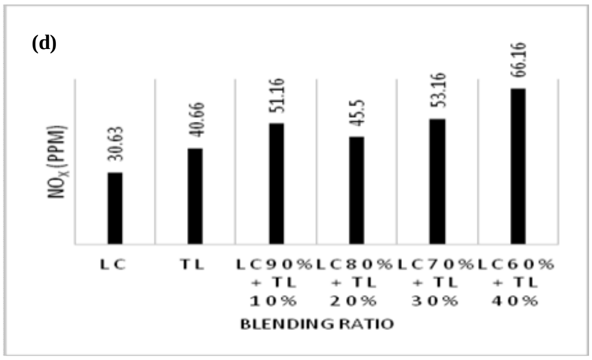


Figure 4. **Effect of different blending ratio of coal and tree leaves on (a) CO, (b) CO_2, (c) NO_x and (d) SO_2**

Conclusion

Comparative study was made by utilizing three different biomass with lignite coal for co-combustion. During co-combustion different blends of biomass and coal were employed for investigating the different ratios at which minimum gaseous emission emits. Minimum emissions of CO, CO_2, NOx and SO_2were observed at 80:20 ratio of lignite coal- cow dung manure and 100% banana tree waste. It was concluded that with addition of biomass up to 30% could make less emission of CO during co-combustion with coal. Furthermore, utilization of biomass with coal could make remedial action against environment pollution.

Acknowledgment

The authors acknowledges to the Chemical Engineering Department, Mehran University of Engineering & Technology, Jamshoro for providing the research facilities to carry out the research.

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