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An investigation of co-combustion municipal sewage sludge with biomass in a 20 kW BFB combustor under air-fired and oxygen-enriched condition

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ABSTRACT

The behavior of municipal sewage sludge (MSS) with biomass (Guar stalks (GS), Mustard Husk (MH), Prosopis Juliflora Wood (PJW)) has been investigated in a 20 kW bubbling fluidized bed (BFB) combustor under both air-fired (A-F) and oxygen-enriched (O-E) conditions. The work presented is divided into three parts, first part cover the thermogravimetric analysis (TGA), second part cover the experimental investigation of BFB combustor, and third part covers the ash analysis.

TGA was performed with a ratio of 50%MSS/50%biomass (GS, MH, PJW) and results show that 50% MSS/50%GS has highest combustion characteristic factor (CCF). The experimental investigation of BFB combustor was performed for two different ratios of MSS/biomass (50%/50% and 25%/75%) and the combustion characteristics of blends were distinctive under both A-F and O-E condition. Despite 50%MSS/50% GS showing the highest combustion performance in TGA analysis, it formed agglomerates during burning in BFB. Due to this formation of large amount of agglomerates, de-fluidization was observed in the combustor bed after 65–75 min in A-F conditions. The rate of de-fluidization increased under O-E condition. The de-fluidization problem disappeared when the share of MSS was reduced to 25%, but small amounts of the agglomerate were still present in the bed. With oxygen enhancement, the combustion efficiency of BFB combustor was improved and flue gasses were found within permissible limit. The maximum conceivable combustion efficiency (97.1%) for BFB combustor was accomplished by using 50% MSS/50% PJW under O-E condition. Results show that a ratio of 25%MSS/75%biomass combusted successfully inside the BFB combustor and extensive work is required for efficient utilization of significant share of MSS with biomass. SEM/EDS analyses were performed for agglomerate produced and for the damaged heater to study the surface morphology and compositions. The elemental heterogeneity of fly ash generated during MSS/biomass combustion was analyzed using Microwave Plasma-Atomic Emission Spectroscopy (MP-AES).

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1. Introduction

India being a developing nation is currently facing many challenges like energy security, clean environment, and waste management. The industrial development and growing urbanization have increased the production of municipal sewage sludge (MSS) across the Indian metro cities (Gupta et al., 2015). In the recent year, India takes two major initiative "Make in India" and "Clean India Mission." "Make in India" is an initiative to encourage companies to manufacture their products in India whereas "Clean India Mission" aims to provide a healthy environment for the human being. These efforts will help to gear up the industrial and social growth of the country, but any strategic failure can cause adverse environmental impacts, public health risk, and other socio-economic problem. To accomplish these goals, India requires to implement or test new advanced technologies for energy security, clean environment, and waste management.

The primary methods used earlier for disposal of MSS are landfill, dumping in the sea, recycling in agriculture, and incinerations. Most of the landfills in India are overshooting their limit, and due to lack of space for new landfills, these landfills are continuing to a function which emits the harmful gasses (Modak et al., 2016). Dumping in a sea of MSS is restricted due to their diversified effect on the aqua system. Some of MSS products are not suitable for the agriculture (Usman et al., 2012), so its use in the agricultural sector

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