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Emissions testing of loose biomass in Limpopo Province of South Africa

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Abstract

Southern Africa depends on wood for energy. This affects deforestation and global warming. Loose biomass briquettes can replace round wood and mitigate such problems. Loose biomass derived from agricultural and forestry waste has chemicals like pesticides which can cause unsafe emissions. This paper studies emissions resulting from combustion of such loose biomass collected from Limpopo, a province of South Africa. Twelve loose biomass samples were tested for gases emitted from domestic stove combustion. Exhaust gases were sampled and tested to determine composition and quantities of emitted elements. Both element identification and particulate analysis are reported.

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Keywords: Emissions; gases; Loose Biomass; Biomass Briquettes; Combustion

1. Introduction

Emissions resulting from biomass combustion are characteristic of the material composition. During combustion, gases and particles such as CO, CO2 and NO2, polyromantic hydrocarbons and methane can be emitted. The composition of the emissions depends also on the nature of the combustion i.e. complete or incomplete. These emissions can have an impact on human health. Particulate matter and certain oxides such as sulphur oxides have been known to affect the respiratory system [1]. Emissions in domestic applications have been subjects of a number of investigations. Ravichandran and Corscadden [2], investigated and compared the gases and particulates emitted

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by a domestic wood stove. The aim was to reduce emissions of gases and particulate matter during the combustion of briquettes. Although certain leaching techniques were applied to the fuel, no significant improvement in emissions was obtained. Similar work conducted in Poland using a small retort boiler burning biomass pellets produced from wood, wheat straws and rape straws found that all pellet types emit less CO, but wood pellets produced a high concentration of toxic Formaldehyde and Benzene [3]. Wheat and rape straws also exhibited small VOC concentration in flue gases. Similar work by Boman [4] on round wood and pellets also reported that wood emits high amounts hydrocarbons (VOC and PAH) and particulate matter. Furthermore, pellets were found to have more controllable and optimized combustion with less emissions. Some of the emitted elements can be attributed to chemicals used during production of the biomass. Agricultural loose biomass contains significant amounts of nitrogen mostly due to fertilization. Qian et al [5] investigated the NO emissions of high nitrogen content biomass using ID 0.45m pilot scale vortex fluidized bed combustor (VFBC). Stock material included rice husks, corn and soya beans. The levels of NOX in the emissions could be adjusted by changing combustion parameters of the VFBC.

In India, investigations were conducted to estimate the gaseous and particulate matter produced by garden biomass as fuel combusted inside a SIFT chamber [6]. Stock materials included grass, leaves, twigs and mixed proportions of all products. Results indicated grass to have low emissions, less toxicity and 10% PM of fine particles with 70% respirable particle fraction, leaves had high non-respirable particulate matter. Leaves and twigs had lower emissions of CO, NO, CO2 compared to grass. In Brazil, an investigation on chemical characterization, combustion, gas and particulate emissions between soft wood and hard wood using Data Ram 4 and Cascade Impactor for PM measurement showed that Araucaria (soft wood) has high lignin content which resulted in high CO emissions during flaming [7]. This led to higher concentration of CO2 and NOx compared to hard woods. Similar results were reported by Sultana and Kurma [8] who investigated high lignin biomass pellets developed from agricultural residue. The high emission of nitrogen was attributed to high content of nitrogen from fertilizers. They also reported that pellets showed positive results in terms of potential to offset substantial amount of GHG emissions.

The main challenge with biomass emissions (especially emissions from loose biomass) is the lack of knowledge on potential health implications. Loose biomass has not been effectively used as a source of energy especially in Sub-Saharan Africa which mainly depends on round wood for energy. If rural communities are to harness loose biomass as a sustainable source of energy, more investigations are required to understand the nature and quantities of emissions produced from their combustion. Research estimates at least 13 million deaths per year as a result of three major risk factors which include indoor pollution [9]. Smit et al [10], investigated methods to reduce air pollution from biomass combustion which has been reported to contribute significantly to childhood pneumonia infections in Guatemala. The aim was to assess the impact of using in-door and open fire wood for cooking. The tests consisted of pregnant women and young infants where open fire had a high number of people and in-door with less number of people. The results indicated high infection of pneumonia for infants. It was also reported that the chimney reduced the risk in open fires by a factor of 50% as shown by a significant drop in child mortality.

2. Experimental Program

2.1. Aim of the Investigation

The aim of this investigation was to determine the emissions from combusting loose biomass freely available in a location in the Limpopo region of Northern South Africa.

2.2. Materials

Twelve different types of loose biomass were collected from freely available forest and agricultural residues. These included maize stalks, maize leaves, grass (yellow thatching grass), ground nut stems, ground nut leaves, ground nut shells, wall nut shells, coconut shells, cow dung, sugar cane leaves, blue gum saw dust and Mopani leaves and bark. These materials were collected from Maphophe Village (Vhembe District) and Vuwani Village (Levubu District) located in the Northern Limpopo Province of South Africa.