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Chemical Characterization of the Particulate Matters Emitted from Biomass Burning in the Cooking Stoves in Bangladesh

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Introduction

Biomass burning (BB) emits particulate matter (PM) and gaseous pollutants in the atmosphere among which carbonaceous species (Black Carbon, Brown Carbon and Organic Carbon) are the most important [1]. BC absorbs solar radiation in the near IR region whereas BrC shows absorption in the UV visible region, both warms the Earth and heated the atmosphere [2, 3]. Atmospheric BrC could contribute nearly 19% of the total absorption by anthropogenic aerosols, whereas 72% is attributable to that from BC [4]. In Bangladesh almost 80% people are living in the rural areas, 70% of them are using varieties of biomasses for cooking of their daily meals which causes serious indoor air pollution and contributes to 78,000 premature deaths on an annual basis [5]. Therefore emission from biomass burning is very important.

Materials and Methods

Seven different biomass species, e.g., rain tree- *Samanea semen*, mango tree - *Mangifera indica*, jackfruit tree - *Artocarpus heterophyllus*, albizia tree - *Albizia julibrissin*, mahogany tree - *Swietenia mahogany*, cow dung, and dry leaves of mahogany tree were burned in the cooking stove (Figure-1) with a size of 4 inches.

Before PM sampling each filter was heated at 800°C for 4 hours to remove impurities. The sample holder filled with quartz filters were placed about 31 cm top of the cooking stove. When individual biomass species (50.0 g) was burned, PM was deposited in the filter and mass was calculated from the differences between PM loaded and unloaded filters. The volume of air was recorded from the difference between initial and final gas meter reading.

Black carbon (BC) and brown carbon (BrC) concentrations were determined with an Aethalometer (Magee scientific soot scan™ model OT21). Δ-C value was calculated from the difference between BC and BrC. TOC analyzer was used to determine total organic carbon (TOC), and Atomic Absorption Spectrophotometer (AAS) was used for selected trace metals analysis.

Fig- 1:Experimental set up for burning of biomass species

Fig- 2: Dry leaves of mahogany

Fig- 2: Biomass burning in laboratory

Objectives

- Determine the concentration of BC and BrC from biomass burning of seven different species.
- Calculate the Delta-C (Δ-C) value for different biomass species.
- Measure the total organic carbon (TOC) in biomass burning emissions.
- Estimate the trace metal concentrations in particulate matters (PM)
- Comparison of the emission level of seven different biomass species

Results and Discussion

Black carbon and brown carbon concentrations:

The average concentration of BC in all biomasses in this experiment was 5.85 μgm^{-3}, whereas; the average concentration of BrC was 12.99 μgm^{-3}.

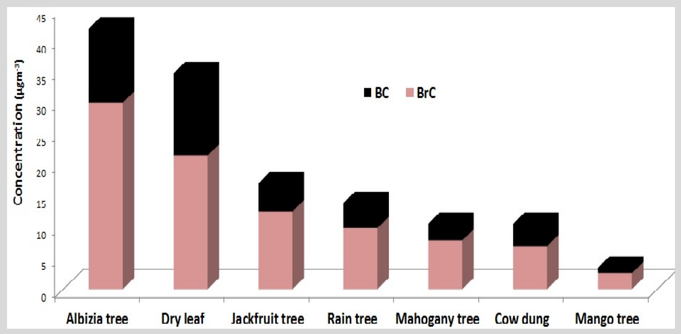

Fig- 4: BC and BrC emission in different biomass species

Delta-C (Δ-C):

Delta-C value was calculated from the differences between BrC and BC for all biomasses according to Wang et al 2011, which qualitatively indicated mass concentration of wood combustion, and also act as a reasonable indicator [6]. The average delta-C value of the determined seven biomasses was 7.16 μgm^{-3}.

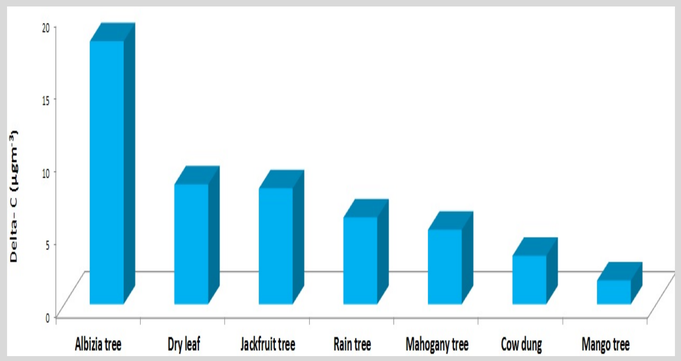

Fig- 5: Delta-C (Δ-C) values in different biomass species

Total organic carbon (TOC):

The total organic carbon concentration was 2.86 ppm on average.

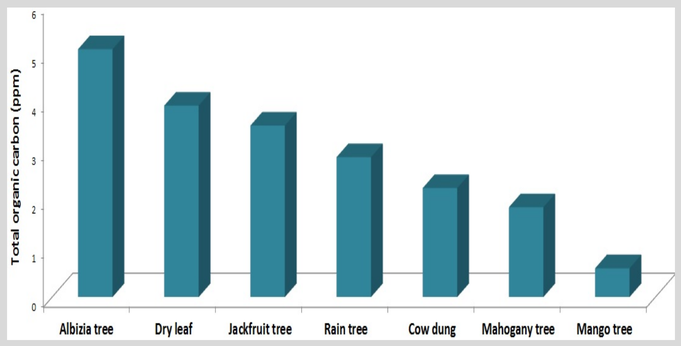

Fig- 6: Total organic carbon present in the considered biomasses.

Trace metals:

Elevated level concentration of the trace metals were observed and they followed the sequence, Ca> Na> Zn> K> Fe> Pb> Cu> Cd. Whereas the Co, Mn and Cr were the below detection limit. However, the emission of trace metals in biomasses also followed the sequence, Dry leaf of mahogany tree> albizia tree> cow dung> mahogany tree> rain tree> mango tree> Jackfruit tree.

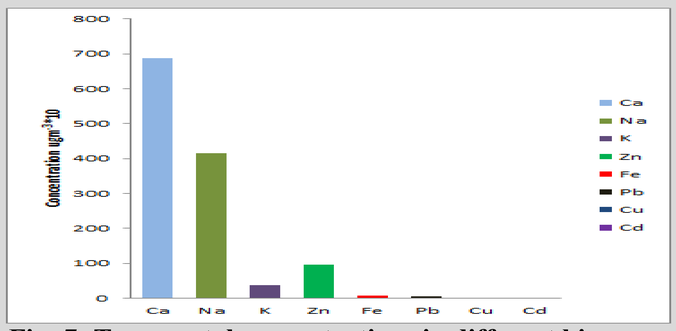

Fig- 7: Trace metal concentrations in different biomass species

Conclusion

- BrC concentration was greater than BC which signifies that biomass species emitted mostly BrC than BC.
- Smoke from albizia tree contains highest amount of BrC whereas, mango tree contains lowest amount of BrC.
- Smoke from dry leaf of mahogany tree contains the highest amount of BC whereas, mango tree contains the lowest.
- The highest delta-C and TOC value was observed in albizia tree whereas, lowest was in mango tree.
- The concentration of Ca and Na were much higher than the others. Among the seven biomass species dry leaf of mahogany tree emits trace metals in highest amount and jackfruit tree emits in lowest amount.
- Mango tree emitted the lowest amount of BC, BrC, delta-C, TOC and lowest amount of trace metals; that signifies the least hazardous impact on the environment by the smoke of mango tree.

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