Characteristics and Ambient Air Effects of Particulate Matters and PAHs from Biomass Combustion in Rubber–Smoking Process

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1. INTRODUCTION

In the production of ribbed smoked sheet (RSS), fuel wood is burned to supply heat to rubber sheets in the rubber smoke room. Burning of fresh wood causes a high concentration of smoke particles which are released into the factory workplace area. The smoke particles from wood combustion contain extremely high concentrations of hazardous pollutants, such as polycyclic aromatic hydrocarbons (PAHs) [2]. PAHs may induce cancer of the lungs, bladder, and skin. Most PAHs are associated with fine airborne particles, typically 0.5 μm or smaller [1]. In addition, PAHs associated with fine airborne particles can be transported over a long distance. This is one of the major sources of air pollution to nearby surroundings.

This research work is aimed at the characterization of the PAHs in the particulate phase in the atmospheric air in the city of Hat Yai, Songkhla Province in southern Thailand and how they are related to biomass (rubber-wood) burning in RSS production. The city is situated in the middle of an area of factories using fuel wood, including several RSS rubber cooperatives.

2. EXPERIMENTAL

2.1 Sample site characteristics

Particulate matter (PM) was collected every month for one year from source (S) and workplace (WP) in Saikao rubber cooperative, and Hat Yai city at Prince of Songkla University (PSU). The Saikao rubber cooperative located around 20 km east- northeast of Hat Yai city, was chosen for studying the characteristic of smoke particles emitted from biomass (rubber-wood) combustion. The Prince of Songkla University (PSU), located in the northeast of Hat Yai city, was chosen for investigating the influences of smoke particles from rubber wood combustion to Hat Yai. This site is representative for a complex mix of pollutants.

2.2 Sampling methods

Particulate matters (PM) have been sampled by three equipment sets: total suspended particulate (TSP) concentration was determined by a commercial high volume sampler (Sibata, HV500F) and a source high volume sampler while PM size distribution of samples was obtained using an Andersen sampler (Dylec, AN200).

2.3 PAHs Extraction and analysis

In this study, 16 PAH compounds are monitored. They include (Nap), (Act), (Ace), (Phe), (Ant), (Fle), (Flu), (Pyr), (BaA), (Chr), (BaP), (BbF), (BkF), (DBA), (IDP), and (BghiPe). PAHs on sampled filters were extracted using an ultrasonic extraction technique. The PAH extracts were analyzed by using high-performance liquid chromatography (Agilent, 1100) with ultraviolet absorption detection (HPLC/UV detection) [3]. The limit of detection (LOD) was defined as the lowest concentration that the detector could provide a signal to noise ratio (S/N) greater than 3. The LOD in this study was determined to be well below 0.1 ng for the analyzed PAHs except Act (0.22 ng). The recovery percentage in this study was found to be in the range of 60-104% for each compound except Nap (47%).

3. RESULTS AND DISCUSSION

The size distribution of the smoke particles shows a single-mode behavior. Mass median aerodynamic diameter (MMAD) was found to be 0.68 μm and the geometric standard deviation (GSD) was 3.04 μm. An average smoke concentration is 15,806.11 μg m^{-3} or mass emission to workplace is 4.33 kg $month^{-1}room^{-1}$. The size distribution of the smoke particles in workplace and PM from PSU shows a bi-modal behavior of aerosol particles dominated by fine particles with a peak at 0.54 μm, an accumulation mode, similar to that from smoke particles and the coarse-mode (peak at 4.00 μm) probably from the soil dust near, building and traffic. The relationship between the TSP and the RSS production are show in Figs. 1 (a) and (b) for workplace and PSU, respectively. Increase of RSS production linearly enhances the TSP.

The relationships between the PAH concentration and the RSS are show in Fig. 2. The correlations exhibit linear increase of 4-6 ring PAH concentration with respect to RSS production for April-August and September-December. On the other hand 4-6 rings PAH concentration during January-March seems to inversely proportion to RSS production. During this period, the wind direction is east-northeast or from the gulf of Thailand.

Fig. 3 compare total PAH concentration in each size range of particles sampled from workplace and PSU. PAH concentration in the workplace is about one order of magnitude higher than that in PSU, in almost all size.

Fig. 4 shows contribution of each PAH to the total mass at each sampling site. The largest contributor to the total mass is difference for particle sampled at each site. The largest contributor to the total mass for source and workplace were 4-6 rings PAHs, 64% and 62% to total mass for source and workplace sampling, respectively. This indicates the direct effect of smoke particles on the atmosphere in the working environment. The largest contributor to the total mass for PSU sampling was, 2-3 ring PAHs which was accounted for 67%. Here, effect of smoke particles to the city of Hat Yai seems to be less than in the workplace.

CONCLUSION

The smoke particle size distribution from source sampling shows a single-mode behavior. Mass median aerodynamic diameter (MMAD) is 0.68 μm. The particle size distributions of workplace and ambient air have bi-modal behavior. The TSP and PAHs in workplace depend on RSS production. Increasing of RSS production linearly enhances TSP. Behaviors of TSP and PAH concentration of aerosol particles from PSU influenced by the precipitation, RSS production and wind direction are in similar fashion. The PAH concentration inside the workplace was high, particularly of ones with larger number of aromatic rings in the fine fraction of particle, which may lead to serious health problem to worker. The PAH distribution patterns are varied with the sampling sites. Particle-bound PAHs from source and workplace were dominated by 4-6 rings PAHs compounds. While, PAHs from PSU were dominated by 2-3 rings PAHs compounds.

ACKNOWLEDGMENTS

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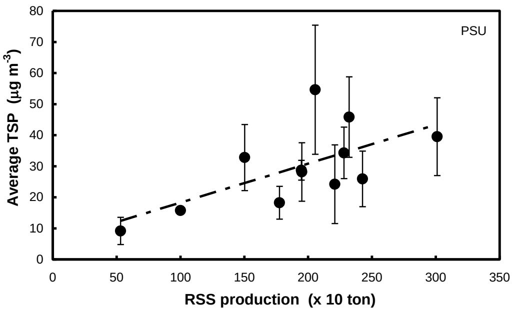
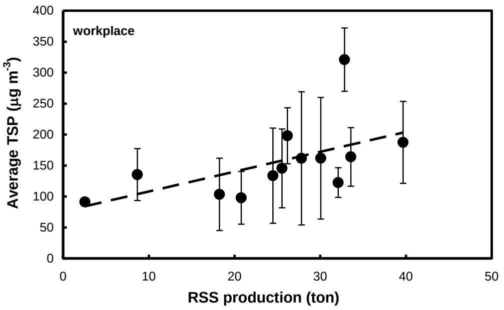


(a)



(b)

Fig. 1 Relationship between the average monthly TSP and the RSS production at (a) workplace area, (b) PSU.

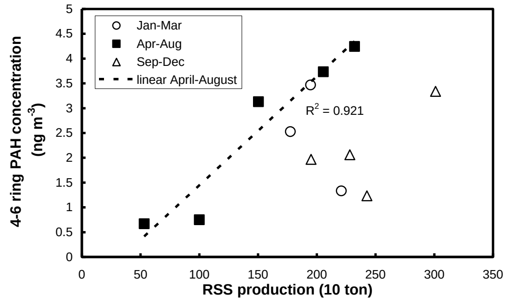


Fig. 2 Relationship between concentrations of 4-6 ring PAHs at PSU and RSS production in 2006.

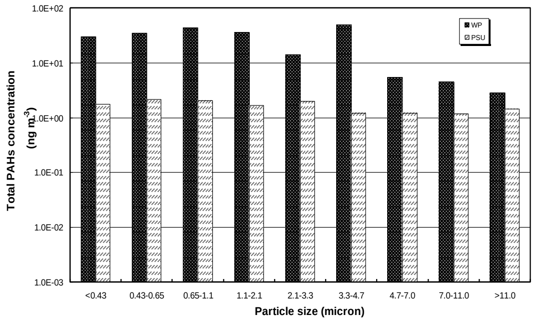


Fig. 3 Total PAH concentration in each size range of particles sampled from workplace and PSU.

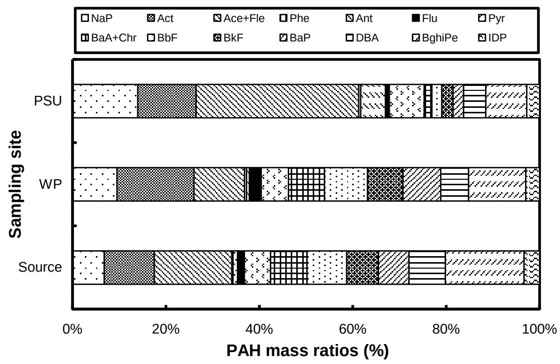


Fig.4 PAHs mass ratios of sample from each sampling site.