Identification and Quantification of Atmospheric Pollutants and Greenhouse Gasses/ Airborne Particulate in Natural and Man-made Ecosystem

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Introduction

Aerosol particles of fine dimensions are recognized to have a strong impact on the environment and to be of concern in health-related effects. The haze that originated from the 1997 Indonesian forest fires was a significant environmental concern. Local input, which aggravated the haze, included open burning, emissions from motor vehicles, especially two-stroke motorcycles, and industrial activities. In less developed regions, vegetation is more prominent source of energy, with large amounts of clearing and burning for cultivation, for heating and cooking, and land management (Cofer *et al.*, 1997). Uncontrolled forest fires of wild fires usually occur during a prolonged dry weather and no rainfall. Biomass burning produces a complex mixture of trace gases and particulate matter into the atmosphere (Mckenzie *et al.*, 1994). These particles can be categorized as carbonaceous aerosols, black carbon, charcoal and fly-ash (Lim et al. and Renberg, 1997). During the 1980s and 1990s, laws restrict to limit the amount of various exhaust emissions from automobile engine was enforced. Although harmful emissions produced by engines have been reduced by over 90% since the 1940s, they are still major environment problems (Pulkrabek, 1997). Worldwide, the number of vehicles in operation has grown from less than 50 million to more than 500million in the last 40 years. That number is estimated to exceed one billion by 2015 (Wark *et al.*, 1998). The burning of biomass during the forest fires as consequences of natural processes or man-made activities are resulting in deterioration of the environment (Chung et al., 1984). In the meantime, research has clearly demonstrated that motor vehicle air pollution can have serious adverse health effects on the population. Our principal goals were to provide a comprehensive physico-chemical characterization of the particulate matter from various sources of air pollution, to examine how trace metal content in airborne particles are associated with the concentration of the particle in ambient air, and to illustrate differences between various sources of suspended particulate matter. In addition to these, we discussed briefly the contribution of various local sources to the composition of suspended particulate matter.

Materials and Methods

Three types of phytomass were chosen as burning materials in the burning experiment. They were grass (lalang; *Imperata cylindrica*), grass mixture (various types of species from grass field) and rice straw (*Oryza saliva L.*). A test chamber (5.51 m^3) was used for the burning experiment. Beside that, the diesel-powered vehicle sampling was carried out aboard the UPM campus and PUSPAKOM Sdn. Bhd. Gases and particulates were collected from the different types of vehicles that using diesel as a fuel such as 4WD, van, pickup, taxi, lorry and bus, which are classified according to the engine capacity of the vehicles. The sampling of two-stroke motorcycles, namely 100 cc and 135 cc were carried out in UPM campus. Gas was sucked to the first chamber (1 m x 0.3 m x 0.3 m) with eight pieces of plate inside where the bigger particulate was trapped inside. Exhaust emission then was channel into the mixing chamber before going to the dilution chamber with total volume of 0.31 m^3. On the other hand, 1g of rice straw and grass were burned respectively in a 3.526m^3 test chamber and the smoke particles were collected by similar method for elemental analysis. Daily samples (24 hours average) of ambient haze particles were also been collected at UPM station (about 23 km from Kuala Lumpur), by utilizing a High Volume Sampler (HVS). Concentrations of gases were measured using a portable multi-gas analyzer (Model 1302; B&K, Denmark) exploiting infrared analysis. Water vapour (H_2O) and carbon dioxide (CO_2) were measured using LI-6262 CO_2/H_2O Analyzer. Particulate matter less than 10μm was collected using high volume sampler (HVS), which is based on gravimetric principles. The morphology of particulate matter on a filter paper was analysed using scanning electron microscopy (SEM) method. Filter papers containing haze sample were selected and analyzed for trace metal contents by using an atomic absorption spectrophotometer (AAS, model: Shimadzu, AA-680). A study on dispersion of air pollutant was also conducted in Shah Alam industrial area. Modeling of the dispersion of the particulate matter was carried out with Gaussian Model. The particulate matter concentration at four downwind distances from the stack location was measured. Simulation of dispersion of particulate matter under varies environment conditions was carried out.

Results and Discussion

C_6H_{14}, C_6H_6, C_8H_8, CH_4, CO, CO_2, H_2S and SO_2 were found to be the major gases from the rice straw, grass or grass mixture burning emission. Small liquid particulates homogenized to liquid clusters were produced from the grass or rice straw burning. Particles on filter paper that exposed to the smoke from the grass mixture burning were in solid partilces of about 1 μm). Low engine capacity motorcycles (100 cc) produced low concentration of SO_2, NH_3, H_2S, $CFCl_3$, SF_6, SO_2, CH_3OH, C_2H_3Cl, C_6H_6, CH_4, C_6H_{14}, C_8H_8 and SF_6 gases emission as compared to higher capacity motorcycles (135 cc).

However, the concentration of CO and particulates weight was higher in smaller capacity compared to the higher engine capacity. SEM analysis showed that the particles from the motorcycle are goblet, liquid-droplet, spherical or crystal-like. Most of the particulate matters from the diesel exhaust emission were in the form of spherical coagulates. The haze particles were smaller than 10µm and majority of these particles had a diameter of less than 2.5µm. It was also clearly observed that the trapped particles were attached to each other (without boundary between adjacent particles). The formation of liquid droplets may be related to the chemical composition of haze particles, which were dominated by organic material (such as tar) from the incomplete combustion, distillation, and recondensation of tarry substances. The liquid droplets, which were joined to each other were forced through the filter during sampling and during vacuum treatment before SEM analysis. The PM_{10} concentrations from the phytomass burning were averaged as 84.65, 63.18 and 49.91 mg/m^3 for 50g of rice straw, grass and grass mixture, respectively. Potassium (K^+), an indicator for biomass burning (Kuang *et al.*, 1998) present at high concentration (44.6 ng/m^3) during haze period compared to that of non-haze period (February 1998) of 5.0 ng/m^3. There was a good correlation between PM_{10} and K^+ concentrations (r^2=0.96) during haze period indicating that the K^+ was originated from forest fires. The long-range transport of K^+ by southwesterly winds from forest fires increased the concentration of K^+ in the local atmosphere. The average concentration of lead (Pb^{2+}), found in this study (10.7 ng/m^3) was much less then the recommended Malaysian Air Quality Guideline of 1.5 $\mu g/m^3$ (90-day average). A poor correlation (r^2=0.58) between PM_{10} and Pb^{2+} concentrations suggested that the atmospheric Pb^{2+} during the haze period was due to a local emission, i.e. motor vehicle emissions. Elements such as Al^{3+}, Fe^{2+}, Cu^{2+} and Zn^{2+} were from soil dust, originated from construction works. The presence of large construction works in the nearby area during sampling periods was reflected by high concentrations of Al^{3+} (338.1 ng/m^3, r^2=0.75), Cu^{2+} (141.5 ng/m^3, r^2=0.42), Zn^{2+} (396.0 ng/m^3, r^2=0.64) and Fe^{2+} (3.1 ng/m^3, r^2=0.86) in the haze samples. Other elements including Cr^{3+}, Co^{2+}, Na^+ and Mg^{2+} could be originated from both natural and industrial emissions. The results displayed that 1g of rice straw combustion may produce 14,463.98 $\mu g/m^3$ of PM_{10} while 1g of grass combustion produced 21,270.56 $\mu g/m^3$ of PM_{10}. It can be seen that the smoke particles from both kind of phytomass burning produce a high concentration of potassium, which is 991.67 $\mu g/m^3$ for rice straw and 890.75 $\mu g/m^3$ for grass. The high concentration of K^+ in the smoke particles from biomass burning and good correlation with PM_{10} concentration (r^2=0.96) during haze period suggested that the presence of potassium in submicron aerosols can be used as a diagnostic tracer for particles of biomass, especially phytomass burning. Even though there was a high concentration of Mg^{2+} in phytomass burning particles, but it showed a poor correlation (r^2=0.63) with PM_{10} concentration during haze period. This showed that Mg^{2+} could be originated from several kinds of air pollution sources. Fe^{2+} showed a wide variation of content either in rice straw or grass burning. Thus, the existing of Fe^{2+} in haze particles could not be a good indicator for biomass burning as overall cases. Zn^{2+} concentration was relatively low in phytomass burning compared to other prominent elements. Insignificant correlation between Zn^{2+} and PM_{10} during the haze period suggested that Zn^{2+} could be also produced by other sources. In contrast to the other elements, Cu^{2+} and Pb^{2+} were not the emission product from rice straw and grass burning. Result of the study indicated that the particulate matter was homogeneous dispersed along the downwind distances. The study also disregards other sources that may emit particulate matter to the air.

Conclusions

Variation chemical composition causes differences emission in every type of plant. CO_2 was the highest concentration compared to the other gases in these phytomass burning. The 2-stroke engine motorcycle produced high concentration of carbon monoxide for 100 cc and 135 cc motorcycles. For the diesel-powered vehicle emission, hydrogen sulfide was the highest. All particles sizes from the diesel-powered vehicles were relatively minute (<1µm diameter) if compared with the phytomass buring or the two-stroke engine motorcycles emission. Similar physico-chemical properties of particles from haze and controlled biomass burning showed that they form liquid droplets and liquid clusters. Rice straw and grass burning produced high concentration of K^+, Fe^{2+} and Mg^{2+}; but there was no Cu^{2+} or Pb^{2+} been produced during those phytomass combustion. A good correlation between PM_{10} and K^+ concentrations (r^2=0.96) during haze period indicated that the K^+ was originated from forest fires. Conversely, the concentration of Pb^{2+} in haze particles showed a poor correlation (r^2=0.58) with PM_{10} suggested that the atmospheric Pb^{2+} during the haze period was due to other local emission.

Benefits from the study

Atmospheric pollutants in natural and man-made ecosystems had been identified and quantified for public awareness and their concern. The findings had been presented in seminar, proceedings, conferences as well as publication in journals. The data is useful to the relevant authorities for the establishment of rules and regulations regarding air quality. The information provides necessary base line data for development of policy, planning and management.

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