Innovative Approaches in Aerosol Science and Air Quality Management: Insights from Recent Research in Thailand

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Abstract

Air quality in Thailand and Southeast Asia (SEA) remains a pressing environmental and public health crisis. Seasonal biomass burning, traffic, and industrial emissions, compounded by transboundary haze, ensure that virtually all residents are exposed to unhealthy air for much of the year. Recent multidisciplinary research in Thailand, as well as collaborative studies in Malaysia and Indonesia, has advanced our understanding of source apportionment, continuing pollutant exposure, and the physicochemical and toxicological properties of aerosols. Key investigations have mapped the impacts of haze and open burning on fine ($PM_{2.5}$ and PM_1) and ultrafine ($PM_{0.1}$) particles, delivering valuable insights for pollutant management. Recently, ultrafine particles have received increasing attention in research due to significant impact on human health. $PM_{0.1}$ concentrations in upper SEA were found in the range 1.5-25.2 μg/m^3 and lower SEA were 1.4-16.8 μg/m^3. Contribution of PM_1 and $PM_{0.1}$ were approximately 50-90% and 5-34% of the $PM_{2.5}$, respectively. PM_1 exhibited a strong correlation with $PM_{2.5}$ not only in terms of mass concentrations but also respect to chemical composition and emission sources, while primary emission sources of $PM_{0.1}$ differ significantly from those of $PM_{2.5}$. Over 60% of $PM_{0.1}$ emissions originate from diesel engine combustion, whereas PM1 and $PM_{2.5}$ emissions are more diverse, arising from both diesel engine combustion and local biomass burning. During haze period, the main source of fine and ultrafine particles in Thailand, accounting for 30-50%, was from biomass burning. This defines a critical issue depending on sources and regions. In the north, most dominant source of air pollutants, especially fine and ultrafine PMs is from forest fires. This follows by agricultural waste burning as well as transboundary sources. The most important motivation in setting the open biomass fires is financial hardship of local people as well as farmers. By burning the forest, they can easily hunt wild animals for food, and collect wild plants to sell in market. Burning agricultural residue is the most economical way to prepare lands for the next crops. Civil movements in the region pose a strong push to government to act on reducing the problem. Synergization of all sectors in the area is the key to success. This has led to policy change and collaboration to solve the problem. In the northeast where most of the burning is from agricultural waste. Motivation is also the same. The only way to avoid burning is farm mechanization. However, this requires huge effort and strong financial support from government. In the south, domestic sources are limited. Major sources of open biomass burning are from small peat swamp forest, similar to peatland in Sumatra and Borneo islands. In the Kuan Kreng peat swamp forest, management of water levels in the area is the key to success in control of forest fires. Prince of Songkla University has initiated a new concept of "PM Debit" to calculate impact from biomass burning in terms of economic values focusing on agricultural sector. This could lead to the use of the indicator in policy setting for management of biomass burning in the future.