PRODUCTION AND CONSUMPTION OF METHYL HALIDES IN SOUTHEAST ASIAN TROPICAL FOREST

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Plants emit a variety of biogenic volatile organic compounds (BVOCs) into the atmosphere. Major BVOCs, such as isoprene and monoterpenes, are extremely reactive and play an integral part in atmospheric chemistry by modulating the oxidation capacity of the atmosphere and providing the formation of organic aerosols. In addition to the reactive compounds, certain tropical plants are known to emit long-lived compounds such as methyl chloride (CH_3Cl) and methyl bromide (CH_3Br). Their atmospheric lifetime (~ 1 year) is long enough for them undergo long-range transport from source regions to the stratosphere, where they play an important role in the halogen-catalyzed destruction of stratospheric ozone. Currently, they are responsible for ~25% of total halogen related ozone depletion and hence important in the global climate system.

The atmospheric budgets of the methyl halides remain highly uncertain, but natural sources are believed to play major roles in the budget of the compounds, especially CH_3Cl. Among a variety of the natural sources, tropical forest ecosystem is now considered as major source of CH_3Cl. In the tropical forest ecosystem, there are both sources and sinks; plants (as well as fungi) and soil bacteria are known to be responsible for production and consumption of CH_3Cl, respectively. Recently, we observed the consumption of CH_3Cl by tropical plant leaf samples, but it is not known to what extent the identified uptake process affect net emission rate of CH_3Cl from tropical plants. The tropical terrestrial source for CH_3Br is less well studied, despite modeling studies suggested that there are unidentified sources of CH_3Br in the tropics. Only a few studies demonstrated that certain tropical trees and tree ferns produce CH_3Br substantially (Blei et al., 2010; Saito and Yokouchi, 2006). Plant leaves uptake of CH_3Br when exposed to high concentrations (Jeffers et al., 1998), but it is unknown if such processes occur at ambient levels.

In this study, we conducted field studies to determine gross production and consumption of CH_3Cl and CH_3Br for some tropical-tree species. Field studies were conducted at the Pasoh Forest Reserve in Peninsular Malaysia. To simultaneously determine production and consumption rates of methyl halides, a stable isotope tracer technique (Rhew et al., 2003) was applied for tropical plants. Branches of tropical plants were enclosed in a Teflon bag. Immediately after enclosure, 2 ml of a standard gas mixture containing $^{13}CH_3Cl$ (5 ppm), $^{13}CH_3Br$, and CFC-113 (5 ppm) in nitrogen was injected into the bag through the injection port, and then air samples in the bag were collected at 3, 13, 23, and 33 min after enclosure. The air samples were analyzed by preconcentration/gas chromatography/mass spectrometry (GC/MS, HP 6890/5973) with the same experimental setup described in elsewhere (Saito et al., 2008).

Of the 9 plant species examined, five consumed CH_3Cl with an average uptake rate of 3 ng g(leaf dry weight)$^{-1}$ h^{-1}. However, gross production rates of CH_3Cl (31 ± 58 ng g(leaf dry weight)$^{-1}$ h^{-1}) mostly exceed the gross consumption rates, leading to large net source overall. The net CH_3Cl emission rates were similar to those reported for dipterocarp trees (Blei et al., 2010; Saito et al., 2008; Yokouchi et al., 2002). In contrast to CH_3Cl, gross uptake rates of CH_3Br (0.2 ± 0.1 ng g(leaf dry weight)$^{-1}$ h^{-1}) were almost balanced against gross production rates (0.2 ± 0.3 ng g(leaf dry weight)$^{-1}$ h^{-1}). The low net emission rates of CH_3Br are consistent with previously reported values of 0.4 (range: <LOD to –2.9) ng g(leaf dry weight)$^{-1}$ h^{-1} for dipterocarp trees in Borneo island (Blei et al., 2010). The measured uptake rates of CH_3Cl and CH_3Br are correlated with each other, suggesting that CH_3Cl and CH_3Br may be consumed by a similar mechanism in or on the leafing branches. The molar ratio of CH_3Cl to CH_3Br (43) is similar to gross uptake rates reported in the boreal forest soil (CH_3Cl:CH_3Br molar uptake ratio: ~39; (Rhew et al., 2003)); microorganisms (such as methylotrophic bacteria) are known to be responsible for at least part of methyl halide consumption in soils (Miller et al., 2004). Considering that a variety of microorganisms dwell in the surface of plant leaves (Leveau, 2009), and that methyl chloride-degrading bacteria present on the leaf surfaces of a CH_3Cl emitting plant (Arabidopsis thaliana)(Nadalig et al., 2011), our observations may be evidence for the consumption of methyl halides by the plant-associated microorganisms.