Seasonal variations of methane sources in South Asia inferred from observations of stable carbon isotope ratio of atmospheric methane

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Various types of methane (CH_4) sources reside in South Asia, including ruminant, rice paddy, biomass burning, fossil fuel industry, and landfills. For effective reduction of CH_4 emissions, observations of stable carbon isotope ratio of CH_4 ($\delta^{13}C$-CH_4) play an important role. The $\delta^{13}C$-CH_4 data provide better understanding of CH_4 emission sources because of distinct $\delta^{13}C$-CH_4signatures for individual source types: −60‰ for microbial, −40‰ for fossil fuel, and −25‰ for biomass burning sources.

Here we present the first observations of atmospheric $\delta^{13}C$-CH_4 at two sites in South Asia. We have performed weekly air sampling at Nainital (29.36˚ N, 79.46˚ E, 1940 m a.s.l.) in the Himalaya mountain area, northern India since 2006 and at Comilla (23.43˚ N, 91.18˚ E, 30 m a.s.l.) in the paddy area, central Bangladesh since 2012. The air samples were analyzed for atmospheric GHGs and related tracers (Nomura et al., submitted to ACP). Using a newly developed measurement system for $\delta^{13}C$-CH_4 (Umezawa et al., JMSJ, 2020), we started $\delta^{13}C$-CH_4 analysis for air samples collected at both sites from August 2018. The observational data were grouped into three seasons for Comilla (from August to November (ASON), from December to March (DJFM) and from April to July (AMJJ)) and two seasons for Nainital (July and August (JA) and others) by considering the monsoon and agricultural cycles in the regions.

Large increases in the CH_4 concentration were observed during ASON and DJFM at Comilla. The relationship between $\delta^{13}C$-$CH_4$and the reciprocal of CH_4 concentration (Keeling plot) at Comilla inferred that the $\delta^{13}C$-CH_4 signature of the CH_4 source was −52‰ for ASON and −45‰ for DJFM, while no significant correlation was found for AMJJ. Our result suggested that 75% of CH_4emission come from microbial sources and 19% from biomass burning during ASON, while the estimated relative contributions are 55% and 39% during DJFM, by assuming that 6% of the total CH_4 emission was from fossil fuels in Bangladesh (EDGAR V4.3.2). These estimates of contribution of biomass burnings to the total CH_4 emission were much higher than those in the EDGAR inventory, suggesting that the EDGAR inventory underestimate the CH_4 emission from biomass burnings in Bangladesh. Our observation also showed higher carbon monoxide (CO) concentrations during DJFM than ASON, consistent with the above results suggesting the large contribution of biomass burnings during DJFM. At Nainital, increases in the CH_4 concentration and decreases in $\delta^{13}C$-CH_4 were observed during JA, although the ranges of variations in the CH_4 concentration and $\delta^{13}C$-CH_4 were much smaller than those at Comilla. The $\delta^{13}C$-CH_4 signature of the regional source was estimated to be −51‰ throughout the year, showing no seasonal variations of CH_4 sources. The Nainital data might represent a typical $\delta^{13}C$-CH_4 signature over the region.

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