Ambient VOCs Pollution in Malaysia: Sources, Environmental Consequences, and Health Impacts

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Abstract

Volatile organic compounds (VOCs) are key air pollutants from anthropogenic and biogenic sources, influencing atmospheric photochemistry and human health. This study investigated VOC concentration variations, sources, photochemical impacts, and health risks across different land-use types (urban, industrial, and background) in Malaysia. Measurements of 30 VOCs were conducted from January 2018 to December 2019 at ten continuous air quality monitoring (CAQM) stations managed by the Malaysian Department of Environment. Source apportionment was performed using the positive matrix factorisation (PMF) model. VOC contributions to ozone formation potential (OFP) and secondary organic aerosol formation potential (SOAFP) were quantified. Health risk assessments (HRA) were conducted for both children and adults. Urban sites recorded the highest VOC levels (125 ± 116 µg/m³ at S3), followed by industrial (112 ± 112 µg/m³ at S4), with the lowest at the background site (55.5 ± 65.4 µg/m³ at S9). Fuel evaporation (28.5%) was the dominant source in urban and industrial areas, while combustion and biogenic sources (29.7%) prevailed in the background area. Alkenes (59.0%) and aromatics (25.9%) were the main contributors to O_3 formation, and aromatic VOCs had the highest SOAFP, ranging from 351 µg/m³ (88.1%) to 2312 µg/m³ (96.7%). Non-carcinogenic risks (HQ and ∑HI) were below 1.00 for all age groups. However, excess lifetime cancer risk (ELCR) for adults exceeded the threshold of 1.00×10^{-6}, indicating a carcinogenic risk from benzene exposure. These findings highlight the need for stricter air quality regulations to mitigate VOC exposure and protect public health in Malaysia.

Keywords: Volatile organic compounds; ozone formation potential; secondary organic aerosols; positive matrix factorisation; health risk assessment.