Characteristics and Sources of Aerosol-bound and Gaseous PFAS in the Near-Surface Atmosphere of Southern Taiwan

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Abstract

Per- and polyfluoroalkyl substances (PFAS) are environmentally persistent and atmospherically mobile compounds with notable potential for long-range transport and regional accumulation. This study investigates PFAS ambient concentrations, compositional patterns, and emission sources across four sites in southern Taiwan—Nanzi (urban/coastal), Pingtung (inland), Xiaoliuqiu (island), and Lulin Mountain (high-altitude background)—based on aerosol-phase sampling of 19 PFAS congeners conducted during both spring and summer of 2024. During spring, total PFAS concentrations were 12.53 pg/m³ at Nanzi, 9.92 pg/m³ at Pingtung, and 9.33 pg/m³ at Xiaoliuqiu, with PFHxA as the dominant species. Episodic accumulation at Xiaoliuqiu, where concentrations reached up to 27.7 pg/m³, was associated with stagnant or low-dispersion meteorological conditions. A significant correlation with total suspended particulates (TSP) suggests TSP may serve as a surrogate indicator for atmospheric PFAS, encompassing both particulate-bound and volatile components. In summer, total concentrations decreased to 7.64 pg/m³ (Nanzi), 2.25 pg/m³ (Pingtung), 3.73 pg/m³ (Xiaoliuqiu), and 7.35 pg/m³ (Lulin). PFOS, PFOA, and PFNA were prevalent at Pingtung and Xiaoliuqiu, whereas PFOA, PFNA, PFUnA, and PFOS dominated at Lulin; 6:2 FTS was additionally detected at Nanzi, reflecting localized industrial inputs. Source apportionment using principal component analysis (PCA) of 32 global PFAS fingerprints, followed by chemical mass balance modeling, revealed textile-related emissions (52.9%) and marine aerosol (35.3%) at Nanzi, while Xiaoliuqiu was largely influenced by marine aerosol (77.8%). These findings provide the first receptor-model-based PFAS source identification for Taiwan's atmosphere and highlight complex seasonal and spatial dynamics in subtropical East Asia.

Keywords: PFAS, Atmospheric Aerosol, Source apportionment, Chemical mass balance, Inverse trajectory