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Investigating Historical Sources of Polycyclic Aromatic Hydrocarbons in a Highly Urbanized River Using Stable and Radiocarbon Isotopes

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Urbanized river systems are susceptible to high loadings of polycyclic aromatic hydrocarbons (PAHs), a ubiquitous class of contaminants derived from a variety of petrogenic and pyrogenic sources. Understanding the temporal distributions and sources of these compounds can provide important insight into the historical impact of human activities and urbanization on riverine pollution. In this study, stable and radiocarbon isotopes were used to examine historical sources of PAHs in dated sediment cores from the Saint-Charles River, a highly urbanized river which passes through the heart of Québec City – the second largest city in the province of Québec, Canada. Total PAH concentrations ranged from 4.0 to 69.3 µg/g and showed a distinct temporal trend, with the highest levels observed between 1972 and 1990, followed by a marked decline post-1990, reflecting efforts to control emissions. For samples pre-1990, radiocarbon isotope values of grouped PAHs demonstrated a predominantly petrogenic/petroleum origin ($\Delta^{14}C$ = -970 ± 16‰). Distribution patterns dominated by high molecular weight (4-6 ring) compounds and relatively ^{13}C-enriched compound-specific carbon isotope values ($\delta^{13}C$ = 25.2 ± 1.2‰) further suggested liquid fossil fuel combustion (i.e., gasoline/diesel soot) as the dominant PAH source in pre-1990 sediments. The decline in PAH concentrations post-1990 is attributed to improved urban management, emission control technologies, and environmental regulations, although the main PAH source (e.g., gasoline/diesel soot) remained unchanged. This study highlights the importance of sediment cores and isotopic analyses in reconstructing historical pollution trends and assessing the effectiveness of regulatory measures and provides critical insight for future environmental management strategies aimed at mitigating pollution and restoring urban aquatic ecosystems.