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Elemental, molecular, and technomaterial antropognenic signatures in Krakow's urban sediments - a comprehensive geochemical assessment.

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Reconstructing the evolution of geochemical processes in cities is critical for urban ecosystem management and provides environmental context for the historical development of urban space. Urban sediments and deposits can act as stratified archives in which technogenic inputs and natural sedimentary units jointly record shifts in land use, industrial activity, fuel consumption, and construction practices. This study applies a multi-proxy approach to evaluate anthropogenic markers preserved in urban deposits of Kraków (SE Poland) and to test whether independent proxies converge toward a coherent reconstruction of changing anthropogenic pressure.

Four stratigraphic profiles were excavated across representative urban settings to depths reaching horizons associated with sediments of a former riverbed. Each profile was documented in detail (sedimentary structure, texture, and abundance/type of artefacts) and sampled at high vertical resolution. We assessed a broad suite of anthropogenic proxies: (i) magnetic particles and magnetic properties as indicators of high-temperature combustion and industrial/traffic-related emissions; (ii) technogenic components, including fragments of construction materials, slags/cinders, and soot; (iii) mineralogical composition; (iv) bulk geochemistry of major and trace elements; and (v) persistent organic pollutants (POPs).

Integrating stratigraphic observations with magnetic, mineralogical, chemical, and organic-contaminant datasets yields an internally consistent record of increasing and changing human impact, aligned with successive phases of urbanization and industrialization. Magnetic and artefact-based proxies primarily track particulate inputs and construction-related transformations, whereas mineralogy and elemental patterns support separation of lithogenic background, river-derived material, and anthropogenic additions. Stratigraphic ordering supports relative chronologies and differentiates intervals dominated by combustion residues from phases characterized by construction and backfilling. Overall, the multi-proxy framework reduces ambiguity inherent to single-indicator interpretations and improves identification of technogenic layers within urban sedimentary archives, supporting their informed use in urban deposit classification, monitoring, and historical environmental assessment.

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