Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.32933

From Atmosphere to Organisms: Radiocarbon and Elemental Tracers of Urban Pollution in Southern Poland

BARBARA M. SENSULA, ALICJA USTRZYCKA AND BARTLOMIEJ TORON

Silesian University of Technology

Urban environments represent complex systems where atmospheric composition, anthropogenic emissions, and biological uptake are closely interconnected. This study presents an integrated assessment of urban pollution in southern Poland by linking atmospheric CO_2 measurements with radiocarbon signatures and elemental composition of pine needles (Pinus sylvestris L.), providing a continuous perspective from air to organisms.

Atmospheric CO_2 monitoring was initiated in Gliwice in 2022, enabling high-frequency concentration measurements and systematic air sampling. CO_2 concentrations were measured using a CARBOCAP GMP-343 analyzer, while radiocarbon ($\Delta^{14}C$) analysis of extracted atmospheric CO_2 was performed using the MICADAS accelerator mass spectrometry system. Data collected between August 2023 and April 2025 show CO_2 concentrations ranging from 428 to 469 ppm and $\Delta^{14}C$ values between −55‰ and −24‰, reflecting seasonal variability and fossil fuel-derived carbon inputs to the urban atmosphere.

To examine the transfer of atmospheric carbon signals into the biosphere, one- and two-year-old pine needles collected since 2014 from multiple sites across the Silesian region were analyzed for radiocarbon content and elemental composition. The radiocarbon signatures of the needles integrate atmospheric CO_2 during the growing season and exhibit spatial variability consistent with urban and industrial emission sources. Elemental analyses reveal widespread deposition and accumulation of silicon, nitrogen, and sulfur, accompanied by elevated concentrations of calcium, iron, aluminum, magnesium, and potassium. Particularly high iron and titanium concentrations were observed in samples collected near a heat and power plant, indicating strong local industrial influence.

The combined atmospheric and biological datasets demonstrate a clear coupling between urban CO_2 emissions, radiocarbon depletion in atmospheric carbon, and its incorporation into plant tissues, alongside the deposition of airborne particulate matter. Overall, the results highlight the effectiveness of integrating atmospheric measurements, radiocarbon analysis, and elemental composition of bioindicators to trace urban pollution and carbon sources in complex urban–industrial environments.

This work was supported by EU funds FSD - 10.25 Development of higher education focused on the needs of the green economy European Funds for Silesia 2021-2027 : The modern methods of the monitoring of the level and isotopic composition of atmospheric CO2 (project no.FESL.10.25-IZ.01-06C9/23-00, PM: Barbara Sensuła) implemented at Silesian University of Technology (2024-2026).