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Urban soil CO_2 emissions: case study from Krakow, southern Poland

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The studies aimed at quantifying carbon balance in urban areas are usually focusing on anthropogenic emissions of CO_2, such as transportation, coal and gas burning in households or local power plants. However, it has been shown that land urbanization also significantly disturbs the soil system, leading to changes in amount of biogenic carbon released into the atmosphere.

The presented study was designed to learn more about carbon transport between the urban soil and the atmosphere, using CO_2 and its carbon isotope composition ($\delta^{13}CO_2$). The static chamber method, coupled with Picarro G2101-i analyzer and the sampling system for 1-liter glass flasks was used to quantify seasonal variability of the soil CO_2flux and its carbon isotope signature. Three observation sites characterized by different degree anthropogenic influence were chosen within the city limits of Krakow, southern Poland. Starting from 2009, at approximately monthly intervals, the soil CO_2 flux and its $\delta^{13}CO_2$ values were determined for each site. Meteorological conditions (pressure, ambient air temperature, humidity) and soil parameters (temperature and water content at 5 cm depth) were also recorded. In the framework of earlier studies, measurements of soil CO_2 flux and its carbon isotope composition were performed for three non-urban ecosystems (grassland, woodland and arable field), all located in southern Poland. The measurements were conducted during the time period January 1998 – December 2000 using chamber method coupled with flask sampling system.

The measurements revealed distinct seasonal fluctuations of the soil CO_2 flux into the atmosphere, with maximum values up to ca. 45 mmol·m^{-2}h^{-1} for urban sites and approximately 20 mmol·m^{-2}h^{-1} for non-urban sites during summer months and around ten times lower values recorded during winter time. Significant differences between the sites were observed. The observed seasonality of the flux was controlled by the respiration activity of the soil which in turned was linked to the soil temperature.

Carbon isotope composition of the soil CO_2 flux revealed only minor fluctuations throughout a year, essentially reflecting the isotopic composition of the soil organic matter and the vegetation type. The measured $\delta^{13}CO_2$ values, varied between ca. –25‰ and –30‰ with less negative $\delta^{13}CO_2$ values recorded during winter. Small differences between individual urban sites were observed for distinct periods of time, although the overall mean $\delta^{13}CO_2$ values turned out to be statistically non-distinguishable. Since urban sites were exposed for considerable period of time (higher than 100 years) to the atmosphere containing CO_2 with more negative $\delta^{13}C$ signature when compared to non-urban locations, it was expected that some systematic differences between urban and non-urban sites may occur in terms of mean $\delta^{13}CO_2$ values of the CO_2 flux. Preliminary calculations suggest that the difference was small, in the order of measurement unceratainty.

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