Urban soil gas geochemistry to identify permeable zones and possible upflow of deep-seated gases at the city of Ourense, Galicia, Spain

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Thermal waters from natural hot springs and boreholes are clear geothermal features of the city of Ourense (Galicia, Spain). The urban area of Ourense is located in the Miño River’s valley which is characterized by two fault systems (NW–SE and NE–SW) that determine the groundwater circulation in the region. The low permeability of the granite and granodiorite only allows fluid circulation throughout faults and fractures transporting the fluid and transferring the heat to the lower elevations in the valley (Araujo 2008; Fernández Portal et al. 2007). During July to August 2019, an intensive soil gas geochemical survey was carried out at urban area of Ourense in order to identify the presence of vertical permeable structures and possible upflow of deep-seated gases. A total of 539 soil gas samples were taken with an average distance of ≈100 m between sampling sites and covering an area about 13Km². In-situ soil CO₂ efflux and soil gas ²²²Rn activity measurements were performed at each sampling site. In addition, soil gas samples at 40 cm depth were collected for chemical (He, Ne, O₂, N₂, CH₄ and CO₂) and isotope (d₁₃C-CO₂ vs. VPDB) analysis by micro-gas chromatography and IRMS, respectively. Soil CO₂ efflux and ²²²Rn activity values ranged from 0.7 to 92 g·m⁻²·d⁻¹ (mean value of 16 g·m⁻²·d⁻¹) and from 2.7 to 743 Bq·m⁻³ (mean value of 73 Bq·m⁻³), respectively. Regarding soil gas He and H₂ concentration, the values ranged from 5.2 to 25.0 ppmV (mean value of 6.2 ppmV) and from 0.5 to 24.9 ppmV (mean value of 1.9 ppmV), respectively. Soil CO₂ concentrations showed a range between 355 and 53,766 ppmV (mean value of 7,824 ppmV) with a range of isotopic ratios from -14.1 to -28.5‰ vs. VPDB (mean value of -22.1 ‰). The binary plot of d₁₃C-CO₂ vs 1/CO₂ concentration suggest the presence of small fractions of CO₂ deep-seated in the soil gas atmosphere (mainly an atmospheric and biogenic gas mixture) of the city of Ourense. Soil CO₂ efflux, soil gas Rn-222 activity and soil gas He, H₂ and CO₂ concentration contour maps were constructed using the sequential Gaussian simulation (sGs) interpolation method. Estimated diffuse CO₂ emission from the study area is about 201 tons per day and about 8 tons per day could be considered deep-seated degassing.
Spatial distribution analysis of the soil gas geochemical data show relatively high values of soil CO\textsubscript{2} efflux and soil gas H\textsubscript{2} concentration at the Chavasqueira-Tinteiro urban sector, while As Burgas and Outariz-Muiño urban sectors showed relatively high values of soil \textsuperscript{222}Rn activity. These results show the usefulness of the soil gas geochemistry to identify permeable zones and possible upflow of deep-seated gases at the city of Ourense.