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Gas hazard assessment at Puerto Naos and La Bombilla inhabited areas, Cumbre Vieja volcano, La Palma, Canary Islands

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The recent volcanic eruption of Cumbre Vieja, on the island of La Palma, has been considered by many to be the most important and devastating urban eruption of the last 100 years in Europe. After its completion on December 13, 2021, some urban areas not directly damaged by lava flows are affected by strong carbon dioxide (CO₂) emissions from the soil. CO₂ is a toxic gas at high concentration, as well as an asphyxiant gas and may be lethal when present in concentrations higher than 15 V%. The base of the small cliff where the La Bombilla neighborhood is located as well as the basements and garages of numerous buildings in the town of Puerto Naos, seem to represent leaking pathways along which CO₂ related to the volcanic-hydrothermal activity rises to the surface. In order to assess the hazard represented by the endogenous gas emissions, a scientific observational study was undertaken by means of diffuse CO₂ and H₂S efflux measurements as well as gas sampling from the soil atmosphere at 40cm depth and the measurement of the soil temperature at 15cm and 40cm in 97 points homogeneous distributed at La Bombilla and Puerto Naos, in order to delimit anomalous gas emission zones and to know the emission rates of the measured gases. Also we carried out the installation of a Tunable Diode Laser system to measure continuously the CO₂ air concentrations in the basement of a building at Puerto Naos and three permanent CO₂ monitoring stations. Diffuse CO₂ efflux values measured in the Puerto Naos area were relatively low (between not detected and 24 g m⁻² d⁻¹). However, in numerous points of the built-up area of Puerto Naos, air CO₂ concentration values measured both in the street at a height of about 40 cm and in the lower part of several garage doors were generally over 1-2%V, with some sites with values higher than 20%V. The area with the highest CO₂ diffuse efflux values is located in the La Bombilla neighborhood, reaching values higher than 7 kg m⁻² d⁻¹. δ¹³C-CO₂ values of soil gases ranged from -19.2 to -1.7‰ vs. VPDB, confirming a volcanic-hydrothermal origin for those samples exhibiting high CO₂ effluxes and concentration. No H₂S effluxes as well as air concentrations were registered. During the survey, many animals were found dead due to high concentrations of CO₂ and low levels of O₂ in the air. All these anomalous CO₂ emissions are not associated to thermal anomalies. Results of this study show that in many sites at La Bombilla and Puerto Naos areas there is a dangerous CO₂ air concentration that

exceeds the hazardous thresholds. These zones should be continuously monitored for gas hazard and the multi-measurement approach adopted in the present study is of paramount importance for decision-making of people's return to their homes.