Into the Depths: The Challenges of Belowground VOC Sampling

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Volatile organic compounds (VOCs) serve pivotal functions in the intricate interactions within plant ecosystems, facilitating communication among plants and other biotic constituents such as pollinators and soil organisms. While airborne VOCs have garnered considerable scientific attention, belowground VOCs remain comparatively understudied. Nevertheless, these belowground compounds intricately mediate signaling pathways between plants, soil bacteria, fungi, belowground insects, nematodes, and bacterial consortia. The primary limitation to understanding subterranean VOC dynamics lies in technical challenges. Various methodologies exist for their investigation, including *ex-situ* non-destructive extraction of plants from their substrate for root VOC analysis (emitted VOCs), or root tissue grinding for VOC profiling (VOCs contained therein). *In situ* approaches encompass static methods such as Solid Phase Microextraction (SPME) (placed in an inert tube) and dynamic techniques like Dynamic Headspace Sampling (DHS), employing either air extraction (pull) or injection (push) for sampling (or both in push-pull device). The heterogeneous and complex nature of soil poses challenges in identifying the precise origins of sampled VOCs, which may emanate from bacterial, fungal, root, insect, or organic matter sources. Furthermore, sampling efficacy is contingent upon soil physicochemical parameters such as pH, temperature, and pore size. While controlled environment studies or inert substrate replacements (e.g. glass beads) offer experimental control, they may deviate from ecological realism. We will present the advantages and disadvantages of the different strategies, indicating which scientific questions they are best suited to answer. Additionally, we showcase home-made devices developed in our laboratory, designed to sample belowground VOCs and elucidate their role in plant-plant interactions or allelopathic phenomena.

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