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Anoxic microsites enhance soil carbon storage and respond to management

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Anoxic microsites, zones of oxygen depletion within seemingly oxic soils, are under-explored contributors to soil organic carbon (C) stabilization. How anoxic microsites vary with climate, soil properties, and management and the degree to which anoxic microsites contribute to soil C stabilization remain unknown. Using droplet digital PCR, we quantified anaerobe DNA in soils from four long-term agricultural experiments in the central United States. We used anaerobe abundance as a proxy for anoxic microsites and examined how anoxic microsites varied with soil properties and management, specifically, organic matter amendments, tillage practices, and agricultural use (i.e., comparison to an uncultivated control). Anaerobe abundance was associated with soil properties corresponding to oxygen supply, such as water and clay content, and oxygen demand. Anaerobe abundance also responded to management. Practices that altered oxygen demand (e.g., organic matter amendments and cultivation) had a greater effect on anaerobe abundance than practices that regulated oxygen supply, such as tillage. Finally, anaerobe abundance was positively correlated with soil C concentration. Compared to other mutable soil C protection mechanisms, anoxic microsites explained the greatest unique variance in soil C concentration across cropland soils. Our results suggest that anoxic microsites are ubiquitous and responsive to management, and they can be leveraged to increase soil C storage within agricultural soils.