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Density and porosity as controls on charcoal storage in soils

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A number of studies have documented very low biotic and abiotic decomposition rates of charcoal in the environment, leading to the assumption that it stays within soils after deposition. This assumption forms one tenet of a promising carbon sequestration technique, soil biochar amendment. Laboratory and greenhouse trials with biochar (charcoal produced for addition to soil) do show that charcoal remains in soils after amendment. However, when charcoal has been added to soils in field trials, its retention rate in soils is highly variable. Low retention rates have been reported in some environments, leading to questions about its physical movement across landscapes.

Density and porosity are fundamental physical characteristics that play a key role in determining charcoal soil residence time. Measuring the density of charcoal has been challenging historically because of its very high porosity (approaching 80%), making standard fluid displacement methods of density measurement error-prone. Here we review techniques available to measure the density and porosity of BC, focusing on two measurements: skeletal density (the density of the solid component of BC), and envelope density (the mass of a BC sample divided by the volume of its exterior envelope). We present skeletal and envelope density data for environmental charcoal samples and for a series of laboratory-produced charcoals, showing that the skeletal density of charcoal is significantly greater than 1.0 g/cc, while the envelope density is significantly less than 1.0 g/cc. This difference means that pore connectivity and pore structure will be important to quantify to understand landscape movement of charcoal.