Bulk Density and Particle density

Soil water and air occupy voids in the soil, called **pore spaces**. The pore system in soil provides the conduits for air and water exchange and houses roots and microbes. Soil **porosity** is the amount of pore volume (%age of pore space). A medium textured, well-aggregated soil contains about 50% pore space and is in good condition for plant growth when the pores hold an equal distribution of air and water.

Pore size affects pore activity. Big pores, **Macropores**, facilitate free-water drainage, aeration, evaporation, and gas exchange. **Mesopores**, medium-size pores, are essential to capillary water distribution, and micropores provide water storage sites. Macropores are most prevalent in sandy soils and well-aggregated soils, but can be converted to **micropores** by compaction. Medium-textured soils have an abundance of mesopores. Clays promote aggregation but can also be readily compacted. Clays also increase water storage by providing an abundance of micropores. Organic matter affects porosity through its enhancement of soil aggregation.

Porosity can be calculated if bulk density and particle density are known. Bulk density is soil mass divided by unit volume. In its natural state, a soil's volume includes solids and pores, therefore, a sample must be taken without compaction or crumbling to correctly determine bulk density.

Bulk density = Oven dry soil weight / volume of soil solids and pores

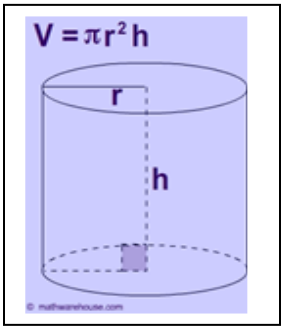
Bulk density of mineral soils commonly ranges from 1.1 to 1.5 g/cm^3 in surface horizons. It increases with depth and tends to be high in sands and compacted pan horizons, and tends to be low in soils with abundant organic matter. Tillage operations soils and temporarily lower bulk density, while

compaction processes raise bulk density. High bulk densities correspond to low porosity. Natural soil-forming processes that increase aggregation reduce bulk density, but excessive tillage and raindrop impact on bare soil destroy aggregation and increase bulk density.

Particle density is the volumetric mass of the solid soil. It differs from bulk density because the volume used does not include pore spaces.

Particle density = oven-dry soil weight / volume of soil solids
Particle density represents the average density of all the minerals composing the soil. For most soils, this value is very near 2.65 g/cm3 because quartz has a density of 2.65 g/cm3 and quartz is usually the dominant mineral. Particle density varies little between minerals and has little practical significance except in the calculation of pore space.

Porosity is that portion of the soil volume occupied by pore spaces. This property does not have to be measured directly since it can be calculated using values determined for bulk density and particle density. Finding the ratio of bulk density to particle density and multiplying by 100 calculates the percent solid space, so subtracting it from 100 gives the % of soil volume that is pore space.



% solid space = (bulk density / particle density) x 100

% porosity = 100 - (% solid space).