Technical Note

Soil Bulk Density and Volume Weight

Introduction

Soil Bulk Density (SBD), also known as the Dry or Field Bulk Density, is a soil physical property that can inform of the nature and composition of a soil, and also the extent of soil compaction. It can also be used to convert analysis results into a 'per hectare' basis. It is simply the ratio of a dried (105°C) mass of soil to a known volume of soil, and is usually expressed as grams per millilitre or grams per cubic centimetre (g/mL or g/cm^3). It should also be noted that the field bulk density test sample must be collected separately to the routine lab samples for nutrient testing i.e. it requires a unique sample.

Volume Weight (VW), previously known as the Lab Bulk Density, is a different measure, being performed after the soil has been dried at 35-38°C and sieved to <2mm. This procedure removes stones and plant residues including roots. A fixed volume of this prepared soil is taken and weighed. This is also the fraction that is used for the routine lab soil tests, and the VW can be used to convert from a volume to weight basis when reporting results. VWs of New Zealand top-soils typically range from 0.4 g/ml to 1.3 g/ml.

Soil Bulk Density

SBD is measured on an un-sieved "as received" sample of soil, most often as an undisturbed core collected under strict conditions. This is a total volume of soil in that it includes solids plus the pore-space, and is therefore a good indicator of soil compaction. Usually a tube or ring of known dimensions is used to collect a core sample, taking care not to compress the sample. The core is weighed then dried at 105°C and re-weighed. The dry mass per cubic centimetre (g/cm^3) is then calculated using the radius and height of the tube or ring to calculate the core volume.

Figure 1 shows typical values of SBD for some New Zealand soils. Topsoils are usually lower in bulk density than subsoils, and soils derived from volcanic ash parent material are lower in SBD than soils derived from sedimentary parent material. Soil high in organic matter, e.g. raw peats have the lowest SBDs.

Table 5.1: Bulk density and porosity of some New Zealand soils (adapted from Soil Bureau, 1968).

Soil series	Group	Horizon	Texture	Bulk density (g cm^{-3})	Porosity (%)
Conroy	Brown-grey earth	A	sandy loam	1.08	57.1
		B	silt loam	1.28	53.8
Timaru	Yellow-grey earth	A	silt loam	1.01	60.0
		B	silt loam	1.68	37.4
Puketeraki	Yellow-brown earth	A	silt loam	0.58	74.7
		B	silt loam	1.01	61.7
Temuka	Gley	A	silty clay loam	0.93	60.2
		B	silty clay loam	1.41	47.2
Taupo	Yellow-brown pumice soil	A	loamy sand	0.57	74.3
		B	sandy loam	0.66	71.0
Egmont	Yellow-brown loam	A	loam	0.66	70.0
		B	loamy sand	0.73	69.5
Hamilton	Brown-granular loam	A	clay loam	0.86	63.6
		B	clay	0.84	67.9
Arapohue	Rendzina	A	clay	0.73	67.5

Fig 1: Typical field bulk density (dry) values for some NZ soils (Source McLaren & Cameron 1990)

For more information, freephone 0508 HILL LAB 44 555 22 mail@hill-labs.co.nz hill-labs.co.nz

Volume Weight

Where a field SBD is not known, the lab VW may be used as a proxy but caution is advised as this is measured on an altered soil and is not truly reflective of the soil bulk density in the field. It can however, suggest something of the soil characteristics by soil type as shown in Table 1.

Table 1: Typical volume weights for soil characterised by various types

Soil Characteristic ("Type")	Volume Weight (g/ml)
Raw Peat	0.4-0.5
Pumice	0.6
Clay	0.8
Sandy	1.0 -1.3

Soil Water Expressions (from SBD measurement)

A number of other reporting measurements are possible from the offered "Ring" profile used for the SBD test at Hill Labs. These are described here:

- Soil Moisture (g/100g) - ratio of the mass of water to the mass of soil and water
  - = (wet wt-dry wt)/wet wt x 100
- Gravimetric Water (g/100g) – ratio of the mass of water to the mass of solids (mass water/mass dry soil)
  - = (wet wt-dry wt)/dry wt x 100
- Volumetric Water (g/100mL) – ratio of a volume of water to volume of soil (volume of water/total volume of soil)
  - = Gravimetric Water x SBD

References

1. McLaren, R.G. and Cameron, K.C. 1990. Soil Science – an introduction to the properties and management of New Zealand soils. p58-60. Oxford University Press, Auckland NZ
2. Soil & Plant Analysis Council. 1992. Handbook on Reference Methods for Soil Analysis. USA. p6-7

For more information, freephone 0508 HILL LAB 44 555 22 mail@hill-labs.co.nz hill-labs.co.nz