Measurements of soil bulk density across differing soil types and land uses in Ireland

Nicola McGoff, James M. Eaton, Ger Kiely, Paul Leahy and Ken Byrne

UNIVERSITY COLLEGE CORK
Coláiste na hOllscoile Corcaigh

Hydromet
Centre for Hydrology, Micrometerology & Climate Change
Dept of Civil & Environmental Eng
University College Cork
Ireland

epa

Abstract

Bulk density estimates add a valuable and missing dimension to understanding Irish soils on the national scale. These estimates are required for calculating stocks of carbon and other nutrients found in soils. Current national estimates of soil organic carbon rely upon bulk density estimates generated from soil properties, such as organic matter, clay content and silt content. Little is known about the accuracy and suitability of applying mathematical estimates of bulk density to Irish soils. Without better knowledge of bulk density and other factors (i.e. the spatial extent of land use classes and soil types) affecting estimates of carbon and nutrient stocks in soils, we can understand nothing of the changes in these stocks over time.

We collected soils at 62 locations (46 mineral soils and 16 peat soils) throughout Ireland to 50 cm depth. Soils sampled included five land use types (arable land, bog, forest, grassland, and rough land) and eight soil types (Acid Brown Earth, Brown Podzolic, Gleys, Grey Brown Podzolic, Lithosol, Podzol, Shallow Brown Earth, and Peat). The bulk density of arable lands varies the least, ranging from 0.9-1.39 g cm^{-3} for top 10 cm of soil and 0.92-1.63 g cm^{-3} for 40-50 cm depth. The variation of bulk density for grassland soils is the largest with estimates of 0.37-1.17 g cm^{-3} for the top 10 cm and 0.16-1.48 g cm^{-3} for 40-50 cm depth. The bulk density of forested sites depends on whether the forest is coniferous or broadleaf. Coniferous forest, often planted on marginal land, have highly organic/peaty soils with low bulk densities, 0.13-1.28 g cm^{-3}. Broadleaf forest, found primarily on mineral soils, have higher bulk densities, 0.58-1.39 g cm^{-3}. Sites with peat soils, such as bog and rough lands, have low bulk densities ranging from 0.07-0.37 g cm^{-3} for the top 10 cm and 0.07-1.18 g cm^{-3} for 40-50cm depth. The high bulk density estimates at depth in bog sites are due to the influence of mineral soils. Knowing these variations in soil bulk densities will facilitate more exact estimate of soil carbon, therefore enabling increased precision in carbon accounting and modeling.

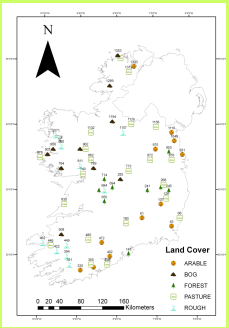


Figure 1: 62 SoilC sites by land use class

Methods

At each of the 62 sites (Figure 1) we laid out a 20 x 20 m square plot (Figure 2). We sampled bulk density at the centre and 4 corners of this plot at the following depths: 0-5, 5-10, 15-20, 20-25, 40-45 and 45-50 cm deep. These were treated as field replicates resulting in 5 bulk density profiles per site. We augured for SOC at 9 points on the square plot, continuously for the following increments: 0-10, 10-25 and 25-50 cm deep. These formed a composite sample, one per depth, and were analyzed for carbon content on an elemental analyzer. This results in 3 SOC values per site. All soils were dried in an oven at 55 C, then sieved through 2mm sieve to remove root and stone content.

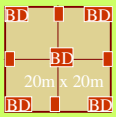


Figure 2: Site sampling layout

Figure 3. bulk density sampler

Figure 5. Bulk density collection

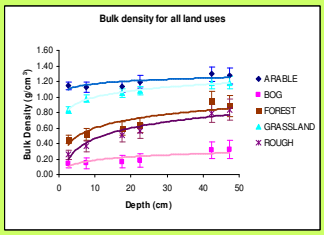


Figure 7: Average bulk density by land use

Results

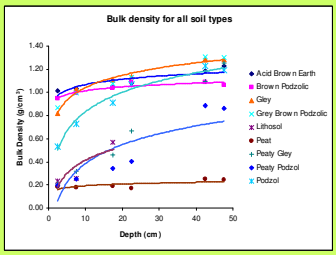
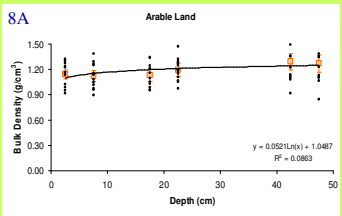


Figure 6: Average bulk density by soil types



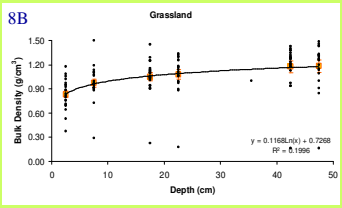
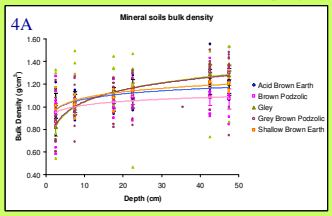
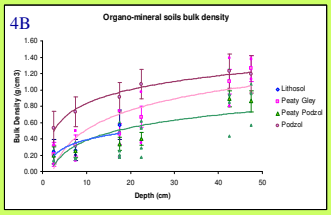


Figure 8. Bulk density values for arable and grasslands. Log regression of the mean, with standard errors.





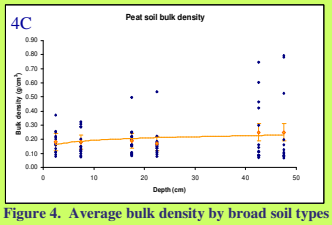
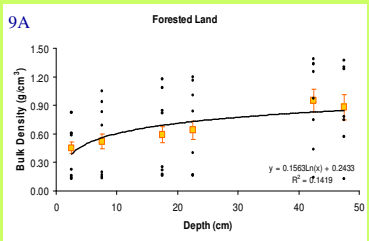


Figure 4. Average bulk density by broad soil types
A: Mineral soils, note Y-axis scale is incomplete.
B: Organo-mineral soils. C: Peat soils.
Log fit curves to the mean values, with standard error bars.

Table 1. Summary bulk density data for each land use type

Land use type	0-10 cm	15-25 cm	45-50 cm
Arable	0.9 – 1.39	0.96 – 1.47	0.92 – 1.63
Grassland	0.37 – 1.17	0.22 – 1.45	0.16 – 1.48
Bog	0.07 – 0.26	0.08 – 0.46	0.07 – 10.7
Rough	0.09 – 0.9	0.14 – 1.13	0.11 – 1.39
Deciduous forest	0.58 – 0.94	0.82 – 1.2	0.74 – 1.39
Coniferous forest	0.13 – 1.05	0.16 – 1.18	0.13 – 1.28



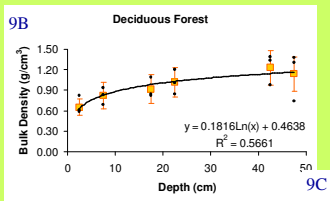
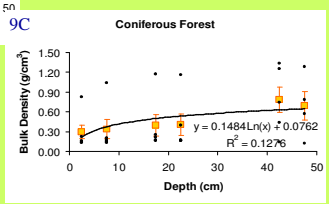


Figure 9. Bulk density values for forested lands.
Log regression lines fitted to the mean, with standard error of the mean.



Conclusions

1. **Bulk density is primarily an inverse function of organic matter content of the soil. Peat has highest organic matter and lowest bulk density.**
2. **Arable has higher bulk density than grassland. As both occur on similar soil types this difference is due to the different land use. This needs clarification through textural analyses and further research into compaction, rooting zones, tillage etc.**
3. **Forest bulk densities need further subdivision in Ireland. Using land cover, deciduous versus coniferous forests, masks the underlying driver of organic content of the soil. Coniferous forests tending to occur on peaty soils.**
4. **Three main soil groups for bulk density: Peat soil, Mineral soil and the highly variable Organo-mineral soil group. Exact soil type is not as important overall.**

Field assistance: Christina LaPerle, Jimmy Casey and all the helpful landowners

Teagasc, Johnstown Castle: Gaelene Kramers , Deidre Fay, Owen Carton

NUI Galway: Chaosheng Zhang

EPA: Alice Wemaere, Project number 2005-S-MS-26

Steering Committee: John Scullion, University of Wales Peter Loveland, Cranfield University

UCD, CreBeo Project: Olaf Schmidt, Christina Hazard, Peter Mullen, Bas Boots, Aidan Keith