

A Comparison of Several Methods for Evaluating Bulk Density of Field Soils

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ABSTRACT

A comparison of several methods for evaluating bulk density of field soils has been made. The methods tried include, sampling with a core of known dimensions, sand cone method, mercury displacement method, kerosene saturation method, kerosene displacement using water as impregnating liquid, coating the soil clods with molten wax to 65 and 100°C, coating the soil clods with collodion, and coating the soil clods with rubber solution of varying dilutions. The results indicated that the method using rubber solution gave a least co-efficient of variation and negligible increase in either volume or weight of soil clods. Other methods gave either high or low values of bulk density or a large coefficient of variation. Relative merits of the various methods have been discussed and possibility of method using rubber solution for routine use indicated.

Several methods have been used to determine the bulk density of field soils. Perhaps the earliest and most commonly used is the core method (King 1914). To this several modifications have been proposed in respect of construction of the metallic core (Dewan 1964), the method of driving the core into the soil and the manner of extraction of the soil sample (Fox & Page-Hanify 1959).

Excavation methods involving in situ measurements of volume of a space from which a known weight of soil has been removed have been used by several workers (Curry 1931; Lutz 1944), but with only a fair degree of success. One of the materials commonly used for the purpose of measuring volume of the excavation is fine sand. More recently Dow Saran Resin has been used to line the soil excavation (Shipp & Matelski 1965), to make the soil impermeable to water and enabling measurement of volume by pouring water in the excavation.

In soils where it is difficult to obtain core samples it has been often possible to compute their bulk density by measuring the volume of soil clods by displacement of a non-wetting liquid like mercury (Haines 1923). Alternatively, the clods can be coated with various materials like paraffin wax (Perry 1942), Saran Resin (Brasher *et al.* 1966) or collodion (Remy 1964), which make the clods impermeable to water and volume determination possible by displacement of water.

A non-polar liquid like kerosene has also been used to determine the volume of clods (McIntyre & Stirk 1954; Russell 1948; Fox 1959). Vershinin *et al.* (1966) developed

TABLE I

Method	Average bulk density (observed)	Coefficient of variation (percentage)	Average bulk density (corrected)	Coefficient of variation (percentage)
Wax Coating (Melted at 65°C)	1.347 ± 0.082	6.07	1.612 ± 0.085	—
Wax Coating (Melted at 100°C)	1.448 ± 0.114	7.87	1.708 ± 0.122	—
Mercury displacement	1.702 ± 0.056	3.29	—	—
Sand cone	1.685 ± 0.052	3.09	—	—
Core	1.636 ± 0.050	3.05	—	—
Kerosene displacement	1.729 ± 0.061	3.53	—	—
Rubber solution 'a'	1.740 ± 0.029	1.70	1.743 ± 0.028	—
Rubber solution 'b'	1.731 ± 0.023	1.33	1.736 ± 0.022	—
Collodion Coating	1.647 ± 0.057	3.46	1.673 ± 0.058	—

RESULTS AND DISCUSSION

Table I gives the average bulk density values, standard deviation and coefficient of variation for different methods. Also included are the values of bulk density corrected for thickness of the coating. Wax (65°C) gave the lowest average corrected bulk density. This is due to the fact that at temperature of 65°C (near melting point of wax) wax does not completely surround the clod and some space is left in irregular depressions between the soil and wax coating resulting in an increase in observed volume and consequently low bulk density. Another disadvantage with this method is that the coating resulting from molten wax at 65°C often cracks when the clod is put in water and the latter penetrates the clod necessitating re-coating of clod before volume measurement can be made. The clods coated with wax at 100°C gave high value of average corrected bulk density. Although at this temperature wax surrounds the clod completely, some wax invariably penetrates into the clods and the volume of this is also included in the correction, giving higher values of corrected bulk density.

Kerosene, although gave nearly the same value for bulk density as rubber solution, the standard deviation and coefficient of variation for this method was much more. The reason for this has to be sought in the assumption that only the excess of kerosene is drained at tension of 10 cms which does not appear to be wholly valid. It appears that some of the larger pores and holes (greater than 1.0 mm dia.) are also drained at this tension. For this reason it was observed that some air bubbles come out when saturated and drained clods were dipped in kerosene for volume measurements. Clods sprayed with water failed to allow volume measurement by displacement of kerosene. As soon as the sprayed clods are dipped, kerosene starts entering the clods and air bubbles come out which is due probably to the fact that films of water (formed by sprayed water) around the oven dried clods are not continuous and thus allow the entry of kerosene.

Mercury gave an average value for bulk density of 1.702, the coefficient of variation was about the same as that when kerosene was the displacing liquid. In this case the extent of pressure applied on the lid to maintain in level of mercury determined to a great extent the amount displaced. Further some mercury invariably enters soil

of the larger pores and making corrections on account of this for individual clods extremely difficult, if not impossible. Above considerations as also the non-applicability of this method to loose and sandy soils, as the clods might break when pressed too hard remain the chief drawbacks of this method.

Sand cone method gave a little lower value of average bulk density but coefficient of variation is nearly the same as that for kerosene and mercury. Many times some sand may go into large holes present in the excavation and this might explain lower value of observed bulk density. Accurately marking the level of the sand on excavation and non homogeneity in the sand are some other possible sources of error in this method.

Core method, although gave comparatively less coefficient of variation than other methods except rubber solution, resulted in somewhat lower value of observed bulk density. This is possibly due to compaction of soil below the core resulting in decreased depth of soils removed by the core and therefore low value of observed bulk density.

Rubber solution 'b' gave an average bulk density of 1.731 and the least standard deviation and coefficient of variation. Rubber solution 'a' gave a little higher coefficient of variation than solution 'b'. This is due to the relatively more viscous nature of solution 'a' which does not penetrate the clod to any appreciable extent. This sometimes results in leakage of the thin membrane at places where there are large holes. This explains a little higher bulk density values obtained by solution 'a' than those obtained when solution 'b' is used.

Collodion gave much higher values for standard deviation and coefficient of variation compared to rubber solution, although these are almost same as for kerosene sand core, and mercury. It forms a relatively thick membrane around the clod (0.32 mm) resulting in lower value of bulk density.

It is further observed from table I that there is a very little difference between the observed and corrected bulk density values and coefficient of variation values for rubber solutions 'a' and 'b' while this is not true for wax and collodion. This is due to the fact that rubber solution forms a very thin membrane (0.0135 and 0.020 mm thickness for rubber solutions 'b' and 'a' respectively) giving rise to negligible increase in volume being of the order 0.200% and 0.246% respectively. Where as collodion forms a very thick membrane and repeated coatings with it results in formation of membrane with entrapped air between the coating resulting in increased volume of the clod.

It would appear from the foregoing that method using rubber solution gives the least standard deviation and coefficient of variation as compared to all other methods studied. There is negligible difference in the observed and corrected values of bulk density indicating that application of correction for routine determination is unnecessary.

REFERENCES

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