SOIL SCIENCE
Vol. 106, No. 6
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Printed in U.S.A.

BULK DENSITY DETERMINATION OF SOIL CLODS USING RUBBER SOLUTION AS A COATING MATERIAL

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Received for publication January 2, 1968

Bulk density is an important soil property requiring frequent determination. A common method of evaluating bulk density includes the determination of oven dry weight of a sample of soil taken with a core of known dimensions. Possible danger of compaction during the process of inserting the core (2) and difficulty encountered in taking samples from hard and stony soils (1) have limited the usage of this method for routine determinations.

Alternatively, bulk density can be computed by determining accurately the volume of a known weight of a soil clod. This is generally accomplished by displacement of a liquid like mercury. Among the many drawbacks of this method are the often expressed doubt that mercury might sometimes enter some of the larger pores, (6), and authors' observations that mercury might not always completely surround some of the depressions in the clods.

Several workers (3, 7 and references therein) have reported that paraffin wax coated clods can be conveniently used for volume determination by displacement of water. Uncertainty regarding the thickness of wax film and the corrections required to account for this makes the method unfit for any precise measurements.

In recent years (1, 5) Saran Resin, a product of Dow Chemical Company, has been used to coat soil clods for making them impermeable to water. Non-availability of this trade product in many places is likely to limit its use.

In an attempt to find a suitable coating material which would make the soil clods impermeable to water and thus enable volume measurements which would not result in any appreciable increase in clod volume, we find that rubber solution is an effective material. The present paper is aimed at suggesting a procedure for bulk density determination of soil clods using rubber solution. The method has been compared with those that use paraffin wax (3) or collodion (4) as coating materials, and their relative efficiency evaluated.

EXPERIMENTAL

Clods used for this investigation were collected from a thin layer (2 inches thick) of hard soil at a depth of one foot from the Punjab Agricultural University Farm at Hissar, India. Since the clods were collected from a thin uniform layer of soil, it is presumed that all clods had a uniform bulk density.

Method of preparation of rubber solution

Rubber is a natural high polymer having a molecular weight on the average of 10,000. When soaked in solvents it does not form true solution but gives a molecular swelling with aromatic hydrocarbons like benzene and toluene. For the present study, crepe rubber or smoke sheets (commercial names for raw rubber) were cut into small pieces and soaked in toluene with the rubber to toluene ratio kept at 1:5 by weight. The mixture was kept overnight in a tight container. Next day benzene was added and the contents thoroughly stirred with the help of an electric stirrer so that swollen rubber pieces were shattered and a homogeneous solution obtained. The solution thus obtained was further diluted with benzene to achieve desired concentrations of 1:30 and 1:40 by weight (hereafter called solutions 'a' and 'b' respectively). Instead of benzene, toluene can be used for dilution but the former has the advantage that it dries out rapidly when applied over the soil clods.

Rubber solution is also commercially available and is used as an adhesive for rubber tubes etc. This can be suitably diluted with benzene for use in bulk density determination of soil clods.

Coating procedure

Clods varying in size were oven dried and coated by four different methods: T_1—Dipped in rubber solution, removed momentarily, and the process repeated four times; T_2—Dipped

in rubber solution until bubbles cease to emerge out from the clods, dried in air for five minutes and then redipped twice as in T_1. T_3—Coated with collodion as described in T_2 for rubber solution. T_4—Dipped once in molten wax at 65°C.

For procedures T_1, T_2 and T_3 clods were held in a thin wire mesh and dipped in the solution placed in a wide mouthed container. Coated clods were kept on a 8 mm sieve for drying. The clods so kept do not stick to the supporting sieve. For procedure T_4, clods were dipped in the usual manner using a thin thread.

Volume measurements

Precise volume measurements of soil clods were made with the help of a two piece flask. It consists essentially of a bottom flask to which is attached a B-50 (2″ diameter) female ground glass joint. To the male joint is attached a graduated tube having a bulb of approximate capacity 30 cm^3 which accommodates a major portion of the displaced water. The coated soil clod is put into the bottom flask and the joint replaced. A known volume of water is added through the graduated tube and the volume of clod read to an accuracy of 0.05 ml. For clods bigger in size, the ground glass joint can be replaced by one of a bigger size or else accurate volume estimates can be obtained by using a cylinder with an attached double S shaped siphon tube wherein displaced water can be measured to an accuracy of one drop (2).

RESULTS AND DISCUSSION

Rubber solution, on drying, forms an extremely thin membrane surrounding the clod, making volume measurements possible. The thickness of the membrane as determined for solutions 'a' and 'b' worked out to be 0.0200 and 0.0135 mm respectively which for the clods studied, corresponds to an average increase in volume of 0.246 and 0.200 per cent respectively, the density of the membrane being 0.806 $gm.cm.^{-3}$. Thus for a clod of 35 $cm.^3$ the increase in volume would be of the order of 0.086 and 0.070 $cm.^3$ respectively for solutions 'a' and 'b', which for all practical purposes can be considered as negligible. Negligibility of these differences is seen from the data on average bulk density of clods for which correction for increased volume has been made and for those where the correction has not been made (table 1). The data indicate that there is slight and rather negligible difference between observed and corrected bulk density for solutions 'a' and 'b', being of the order of 0.003 and 0.004 units respectively. The differences on the other hand are much larger for paraffin wax—obviously because the coating resulting from this material is much thicker, causing increase in volume and therefore comparatively low values of observed bulk density. Lower values of corrected bulk density noted in case of clods coated with wax compared to those coated with rubber solution is due to the fact that at a temperature of 65°C, just above the melting point of wax, paraffin is unable to enter the clods; at the same time some air gaps are left between the clod depressions and the wax coating, resulting in higher volume of the soil clod and therefore a low value of bulk density.

The difference in the observed and corrected values of bulk density when collodion is the coating material is extremely large. This is due to the fact that a correction of 10 per cent for the volume of collodion as suggested by Remy (4) and applied in the present case is too large. There occurs, on the average, an increase in weight of 2.037 per cent which corresponds to a volume of 2.54 per cent. Since some collodion enters the clods and does not contribute to increased volume, and there occurs some increase in volume due to air entrapped in clod depressions; and between the collodion coatings, application of corrections will yield only approximate results.

For the case of rubber solution it is observed that just dipping the clod three times in case of rubber solution 'a' and four times in case of rubber solution 'b' is enough for making the clods completely impermeable to water. Repeated dippings were necessary, since in the first one or two dippings some air bubbles emerged from the clod and ruptured the surface coating making it less effective. Furthermore the clods under study sometimes had holes larger than two millimeters in diameter which did not get surrounded when the clod was dipped just once.

When clods were dipped in rubber solution until no air bubbles escaped, it was noted that dipping only twice in solution 'a' and three

TABLE 1

Standard deviation and average bulk density of soil clods as determined by various methods

Coating Material	Method	Average Bulk Density gm./cm.³		Standard Deviation in Bulk Density		Average* Increase in Weight of Soil Clods after Coating. (%)
		Observed	*Corrected*	*Observed*	*Corrected*	
Rubber solution 'a'	T_1	1.721	1.724	0.0109	0.0255	0.669
	T_2	1.690	1.693	0.0149	0.0111	0.949
Rubber solution 'b'	T_1	1.697	1.701	0.0149	0.0148	0.547
	T_2	1.708	1.712	0.0106	0.0107	0.553
Collodion	T_3	1.728	1.920	0.0335	0.0372	2.037
Paraffin wax	T_4	1.295	1.556	0.0377	0.0315	11.529

* Average of ten determinations.

times in solution 'b' resulted in clods which were completely impermeable to water. It must be stated here, however, that repeated dippings do not result in any increase in the thickness of the surface membrane. This is probably due to the fact that when a clod is redipped in rubber solution the previous coating gets dissolved and penetrates into the clod leaving only a thin coating outside the clod. The rubber solution-dipped clods require nearly 5 to 10 minutes for completely drying out, after which time the volume measurements can be carried out. Contrary to rubber solution, increased number of dippings in collodion result in thicker surface film, and one coating is not effective in making the clods impermeable to water. In many cases even three to four coatings with collodion failed to result in completely impermeable surface coating, and some water invariably entered the clods during volume measurements. It is for this reason that the observed bulk density in the case of collodion coated clods is much the same as that for rubber solution coated clods although the thickness of collodion coating was much greater.

Another advantage which rubber solution appears to have over other coating materials is the complete impermeability of clods after they have been oven dried at 105°C for 24 hours. It is further observed that oven dried clods that had been treated as in T_2 remained impermeable to water even when broken into smaller units. However this is not true for clods treated as in T_1 because there does not occur any appreciable penetration of the solution (table 2) and drying in an oven sometimes results in the rupturing of the surface membrane at places allowing water to enter the clods. The properties of collodion compare well with those of rubber solution as regards permeability after oven drying, but difficulty in obtaining completely impermeable initial coating and danger of increasing the thickness of surface film from repeated coatings remain the chief drawbacks of this coating material.

TABLE 2

Characteristics of different coating materials

Coating Material	Method	Penetration* of Material into the Clod	Permeability** to Water	
			Before oven drying	*After oven drying*
Rubber solution 'a'	T_1	Low	Medium	High
	T_2	High	Nil	Nil
Rubber solution 'b'	T_1	Medium	Nil	Low
	T_2	High	Nil	Nil
Collodion	T_3	High	Medium	High
Paraffin wax	T_4	Nil	Nil	—

* Penetration: Low—less than 1 mm. Medium—1 to 2 mm. High—more than 2 mm.

** Low—escape of less than 2 air bubbles in the first minute after submerging the clods in water. Medium—Escape of 2 to 5 air bubbles in the first minute. High—Escape of more than 5 air bubbles in the first minute.

Because of the promise that rubber solution 'b' and coating procedure T_2 holds for use as a routine method for evaluating the bulk density of soil clods, the same clods as used for coating with wax were taken after removing the wax coat and the bulk density determined using rubber solution 'b' (T_2). An extremely low standard deviation compared with wax coating procedure suggests that the method can be adopted for reliable bulk density determinations on soil clods. Rubber solution has been observed to do well on sandy soils and can effectively waterproof clods taken under field moisture conditions.

SUMMARY

Waterproofing of soil clods using rubber solution is suggested as a preliminary for accurate volume determination of soil clods for their bulk density computation. Treatment with rubber solution does not result in any appreciable increase in either weight or volume of soil clods. From amongst the materials used for coating soil clods (paraffin wax, collodion and rubber solution), rubber solution gave the least average increase in weight and volume on coating, and minimum standard deviation in the observed as well as corrected bulk density values.

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