

**THE GRAVIMETRIC METHOD OF SOIL MOISTURE
DETERMINATION
PART I
A STUDY OF EQUIPMENT, AND METHODOLOGICAL
PROBLEMS**

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Abstract: The type of sampling device, whether a screw or coring auger, is shown to influence moisture determinations. Moisture losses after storage of samples in two different containers for periods up to 7 days are shown to be negligible. Aluminium foil is recommended as a very inexpensive and efficient container. As the rate and length of drying needed for different soils is quite variable, preliminary investigations should be undertaken to establish the times after which negligible losses occur for further periods of drying. In most field studies samples of 50–100 g of soil are adequate; larger samples of 500 g require much longer periods of drying but give similar results.

Methodological problems discussed include the site destruction caused by the gravimetric method and the fact that the method itself accounts for some of the variability found in soil moisture distribution, and possibly for supposedly significant changes in soil moisture content in time and space.

Introduction

Considerable attention has been devoted to soil moisture studies by workers in agriculture, forestry and engineering, and to a lesser extent by geographers^{1–7}). Methods range from the age-old one of feeling the soil to the recent neutron-scattering devices⁸). Although the more elaborate and sophisticated pieces of equipment are becoming increasingly popular, the gravimetric method is still widely used, in particular for the calibration of other methods. A recent review by Cope and Trickett⁹) of the methods available for determining the moisture status of the soil, stresses that many are unsatisfactory in various ways and that the thermo-gravimetric method is still a basic one in general use. Despite its continuing popularity, little study has been made of the technique, and the equipment problems outlined below.

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This paper examines in detail each facet of the method and outlines some of the problems. Later papers examine required sample size in soil moisture studies, and some of the factors influencing soil moisture variability.

Basically, the gravimetric method involves taking a soil sample, weighing, oven-drying, and reweighing it, then expressing the moisture content (*i.e.* the loss in weight) as a percentage of the oven-dry weight of soil. This is the weight or mass basis of expressing soil moisture content. Alternatively, by multiplying by the bulk density, the results may be expressed on a volume basis, and also in inches. For further details of methods of expressing soil moisture results see Lull and Reinhart¹⁰), U.S.A.E. Technical Memoir¹¹); Ven te Chow¹²); Gardner¹³); and Stewart³).

Materials and methods

This section examines the type of equipment used in the sampling, transport, and drying stages of the gravimetric process, the mass of soil sampled and details of the measurements presented in this paper.

SAMPLING INSTRUMENTS

The type of instrument that can be used depends largely on the soil conditions in the area to be sampled. Thus if the soil is excessively stony or very dry then it is often very difficult to use soil tubes or coring devices, and a screw auger or even a spade may have to be employed. Probably the most commonly used instrument in the United States is the King tube or the modified Veihmeyer tube ^{10,14,15}). This consists of a pipe of about 2.5 cm diameter obtainable in lengths from 91 cm to 6.1 metres. A hammer is needed to drive the tubes into the ground and a specially designed jack is often necessary to retrieve them. Stace and Palm¹⁶) have designed a similar tube.

Other sampling instruments include the orchard auger, the Porter piston sampler, the post hole or jarret auger, called an Iowan auger by Lull and Reinhart¹⁰) (this is especially useful in stony soil or where large samples are required), the Pomona open-drive sampler, and the Johnson open drive sampler¹⁴). The last two employ the plunger principle to push out the sample core. A similar device is used by the author. Although retailed as a rock sampling auger, it has been very successfully adapted to soil moisture work.*

The coring section has internal dimensions of 3.2 (diameter) × 7 cm and a

* Cutrock Auger ex: J. Stewart, 406 Strand W.C. 2.

short rod is used to push the sample from the auger into a container. Like most coring devices it is often difficult to use when the ground is very dry or stony, but the author has successfully used it over a wide range of soil conditions from the sticky clays of the Somerset Level margins to the very stony slope soils of Exmoor. In both soils, it was used to take samples from the surface 60 cm. Despite the inevitable slight compaction, soil cores of approximately 3×6.4 cm can be obtained for rapid calculation of bulk density values. Several prototype augers incorporating the principle of a removable inner sleeve were designed by Dr R. C. Hills at Bristol but initial results were disappointing (personal communication).

The type of auger that is probably most widely used in soil moisture sampling is the simple screw auger, which is especially useful in sampling heavy clays or stony soils. However, it is much slower to use than a coring auger because of the time taken to transfer the sample to a container. Also, results have to be expressed on a weight basis because volume measurements cannot be taken from the disturbed sample.

A subject which is little discussed in the literature is the influence of the type of auger on the soil moisture results obtained. This may depend to some extent on the soil type being sampled, that is whether it is stony or fine textured. Estimates of the mean and the magnitude of variability of a soil moisture population made with a screw auger may differ markedly from those made with a coring auger. Part of the answer is that a coring device tends to pick up stones whereas a screw auger pushes them aside. As stones contribute much in weight and little in moisture, the stonier the soil (in terms of the core diameter) the more the moisture content figure is depressed, unless a correction for stone content is made. (This laborious process is considered in Part II of this paper.) Gardner¹³) has a useful discussion of these points.

A series of samples, each consisting of twenty individuals, was collected from thirty 3.1×1.9 m plots to investigate the influence of the type of auger. Ten of the twenty individuals were collected with a screw auger and ten with a coring auger.

SAMPLE CONTAINERS

The type of container used in most reported studies is a tinned can of varying dimensions. Lull and Reinhart¹⁰) suggest that samples may be placed in cans having capacities of 85, 115, 230, 450, and 905 ml.

Some workers transfer samples from field containers to special laboratory containers before placing them in the drying oven¹⁷). This method is liable to cause an error in the moisture determination, especially if there is very little contact between the soil and the sides of the containers, because often

condensation of moisture takes place on the inside of the container. This moisture is lost in transferring the sample and the moisture content is underestimated. With the containers listed below this problem is minimized, because on arrival in the laboratory they are wiped clean on the outside, weighed and placed directly in the oven. Only the cork is removed. Plastic bags can be used as sample containers, loss of weight being negligible, even for periods of a month. However, moisture condensation, soil adhesion and the fact that they cannot be placed into the drying oven, are serious limiting factors.

Three main types of containers have been used by the author:

1. Corked flat bottomed glass tubes of dimensions 7.6×3.8 cm – these were mainly used with the special coring auger mentioned above, but can also be used for screw auger samples.

2. Corked flat bottomed glass tubes of dimensions 10.2×2.5 cm – used for screw auger samples.

Glass tubes were used because aluminium containers were not available. If available, the latter should be used.

3. Aluminium foil – because glass tubes are expensive and liable to breakage if great care is not taken (special packing cases are needed for the transport of large numbers), increased use has been made of ordinary kitchen aluminium foil. This can be used with screw or coring auger samples, but is probably best suited to the latter. The best method of marking foil samples is either to insert a small numbered piece of paper with the sample, or to attach it to a flap of foil with a paper clip. Weighing takes place in the foil which is then opened out for drying. These tend to take up more room than glass containers. An important consideration when choosing a container for a particular experiment is the time that will elapse between sampling and weighing. Frequently as much as 4–8 hr may elapse before the samples can be weighed and in exceptional circumstances this may become a period of a week. Therefore the sample container should be chosen (a) to fit the particular physical size of sample being used, and (b) to allow for any delay in weighing of samples. Hughes and Hatchett¹⁷⁾ determined the time samples in different containers can be exposed to drying without losing a significant amount of moisture before being weighed. “All samples lost a significant amount of moisture when weighing was delayed twenty-four hours.” However, some tests by Lull and Reinhart¹⁰⁾ suggest no moisture losses from self-sealing cans after two days, and even after twenty nine days losses average only 1% by weight.

Similar tests, in hot and cold storage conditions, were undertaken with the 7.6×3.8 cm glass tubes (with two different methods of sealing) and aluminium foil, each container type being replicated ten times.

BALANCES, OVENS AND DRYING TIME

Samples of less than 100 g are usually weighed to the nearest tenth of a gram. To enable large numbers of samples to be weighed speedily, a Mettler top loading automatic balance or an Oertling R20 with a pre-weighing device is very useful. For larger samples, a less accurate balance of the Cenco 3562 type can be read to 0.2 of a gram up to 15 kg if great care is taken, and generally an accuracy of 0.5 of a gram can be achieved.

Samples are generally oven dried at 105–110°C, to a constant weight. Efficient drying ovens include the Griffin-Grundy Model 2/200 and for very large samples the Hurricane Forced Air drying oven made by Wessberg and Tulander Pty. Ltd.

A 24 hour period of drying is generally used. Some workers suggest shorter periods of drying, thus Kut'Ko¹⁸) states that there is a difference of only 0.1% between soil moisture values determined by drying soil for 2 hr against 6 hr. There are three important factors which should be considered when using these average drying temperatures and times:

- 1) Loss of organic matter by oxidation probably begins at temperatures as low as 50°C (Gardner¹³). If 105–110°C is used then this must be accepted as a variable error factor in each result.

- 2) If an arbitrary time period is selected the sample may still contain a great deal of moisture at the end of the drying period. This is in addition to the very small quantities held under considerable tension by the soil particles (Gardner¹³), p. 84; "definition of the dry state"). Some workers accept this as reasonable and use an arbitrary period, because they infer that the moisture figures although not absolutely correct will be sufficiently accurate relative to each other, but

- 3) Because samples from so-called uniform soil have differing rates of drying even this may introduce yet another error.

On removal from the oven, the samples must be cooled in a desiccator (or they will rapidly gain moisture from the atmosphere) and reweighed. Some methods attempt to avoid the long period of oven drying by adding alcohol to the soil, igniting and thus evaporating (some of) the water.^{13, 9)} The drying rates of Windmill Hill and Exmoor Soils were examined.

SIZE OR MASS OF SAMPLE

The amounts of soil used for moisture determinations do not seem to have been based upon any specific studies of physical size of sample, but have usually been decided rather arbitrarily by individual workers.

Krynine¹⁹⁾ stated that "in taking samples for determining the moisture

content of an earth mass, one should be very careful to extract such portions as are true representatives of the whole mass. As a rule, more reliable results are obtained by *large samples*". As far back as 1920 Noyes and Trost²⁰⁾ reported that samples weighing less than 10 g were unsatisfactory for the accurate determination of soil moisture content, yet Bear²¹⁾ indicates that only 2 g of soil are needed for a soil moisture determination. The British Standards Booklet²²⁾ states that a sample of at least 30 g of soil should be used, while Eastwell²³⁾ suggests 100 g.

A series of samples was collected to illustrate the influence of the physical size of sample on the mean moisture content and the degree of variability. The samples collected ranged in size from approximately 15–500 g (Table 3) and were taken from plots 3.1 × 1.9 m in size on a clay loam soil.

Results

SAMPLING INSTRUMENTS

The results in Table 1 illustrate the influence of the screw and the coring auger on soil moisture determinations. While they do not provide any definite proof of a particular relationship, some limited conclusions can be drawn. Where the soil was fine textured, the coring auger gave the much higher soil moisture results; where a stony soil was sampled, the screw auger values were higher than the core auger values. The explanation for the depression of the core moisture values when numerous stones are present, was given above.

The reason for the higher mean values with the coring auger where few large stones (3.2 cm) were present in the soil is probably related to the way

TABLE 1
The influence of the type of auger on soil moisture results

	Textural state of soil		Type of Auger		Mean ¹ moisture content	Best estimate of standard deviation	Coefficient of variation %
	Fine	Stony	Core	Screw			
1. Long Ashton A	*		*		37.3	2.24	5.7
2. Long Ashton A	*			*	27.9	3.13	10.6
3. Long Ashton B		*	*		24.3	3.88	10.9
4. Long Ashton B		*		*	33.9	1.66	6.5
5. Exmoor A		*	*		48.1	3.73	7.4
6. Exmoor A		*		*	52.5	5.55	10.0
7. Exmoor B	*		*		62.9	8.67	13.2
8. Exmoor B	*			*	45.4	5.31	11.1

¹ Each figure represents the mean of 10 individuals.

the sample was taken. The cores were from the top 7.6 cm of soil and were pushed into containers without being touched by hand. It was difficult to keep the screw auger at exactly the same depth, and therefore there was a tendency to sample zones of drier soil, and also to push aside the many plants and roots which inevitably get into a core sample. Also the screw auger samples were touched much more by hand, and were more exposed to drying.

In terms of variability, the results were inconclusive.

SAMPLE CONTAINERS

Data for the glass tubes and aluminium foil are contained in Table 2. Moisture losses after twenty-four hours from all containers and both places of storage were almost nil. Even after 7 days losses were still negligible – the greatest loss being just over 1% by weight from the foil in the hot room.

Possibly losses would have been higher if one set of samples had been stored in the open air, where temperature changes would be greater.

DRYING TIME

The very different lengths of drying time for the Exmoor and Windmill Hill samples are illustrated in Fig. 1. A period of 25 hr was adopted for the Windmill Hill samples and one of 48 hr for those from Exmoor. It is also demonstrated in Fig. 1 that a number of the 10 individuals making up each sample have drying rates which differ significantly from the general trend.

SIZE OR MASS OF SAMPLE

A series of analysis of variance tests (Table 4) on the mean moisture values of the four container sizes at first suggested that the very large samples (of 400–500 g) gave lower moisture results. However, it was found that if the larger samples were oven-dried for longer periods (up to 90 hr) then there was no significant difference between the means at the 95 and 99% levels. The larger the sample the more difficult it is to dry out the middle portion of soil. Therefore, it can be suggested that for a fine textured soil at least, samples in the 15–500 g range give similar moisture determinations.

Unfortunately, samples smaller than 10 g were not collected; but it is felt that in most field studies a sample of about 50–100 g of soil is reasonable. Where the soil is relatively fine textured a sample of approximately 50 g is adequate; where the soil is much stonier (*i.e.* with a proportion of fragments greater than 2 mm in size) then a sample mass of more than 80–100 g is recommended.

TABLE 2
Mean soil moisture losses by place of storage, type of container and time exposed to drying

Place of storage	Type of container	2 hr	5 hr	10 hr	24 hr	48 hr	168 hr	Moisture losses % 2 hr-168 hr
In hot room (temperature 16-18°C)	Foil	36.663	36.632	36.590	36.514	36.349	35.538	- 1.125
	Tube and cello-tape and vaseline	41.010	40.983	40.974	40.961	40.914	40.775	- .235
	Tube and cello-tape	42.831	42.804	42.801	42.789	42.752	42.619	- .212
In cold room (temperature 8-10°C)	Foil	40.244	40.221	40.205	40.178	40.114	39.882	- .362
	Tube and cello-tape and vaseline	44.686	44.673	44.679	44.685	44.656	44.649	- .037
	Tube and cello-tape	47.404	47.396	47.403	47.414	47.389	47.421	+ .017

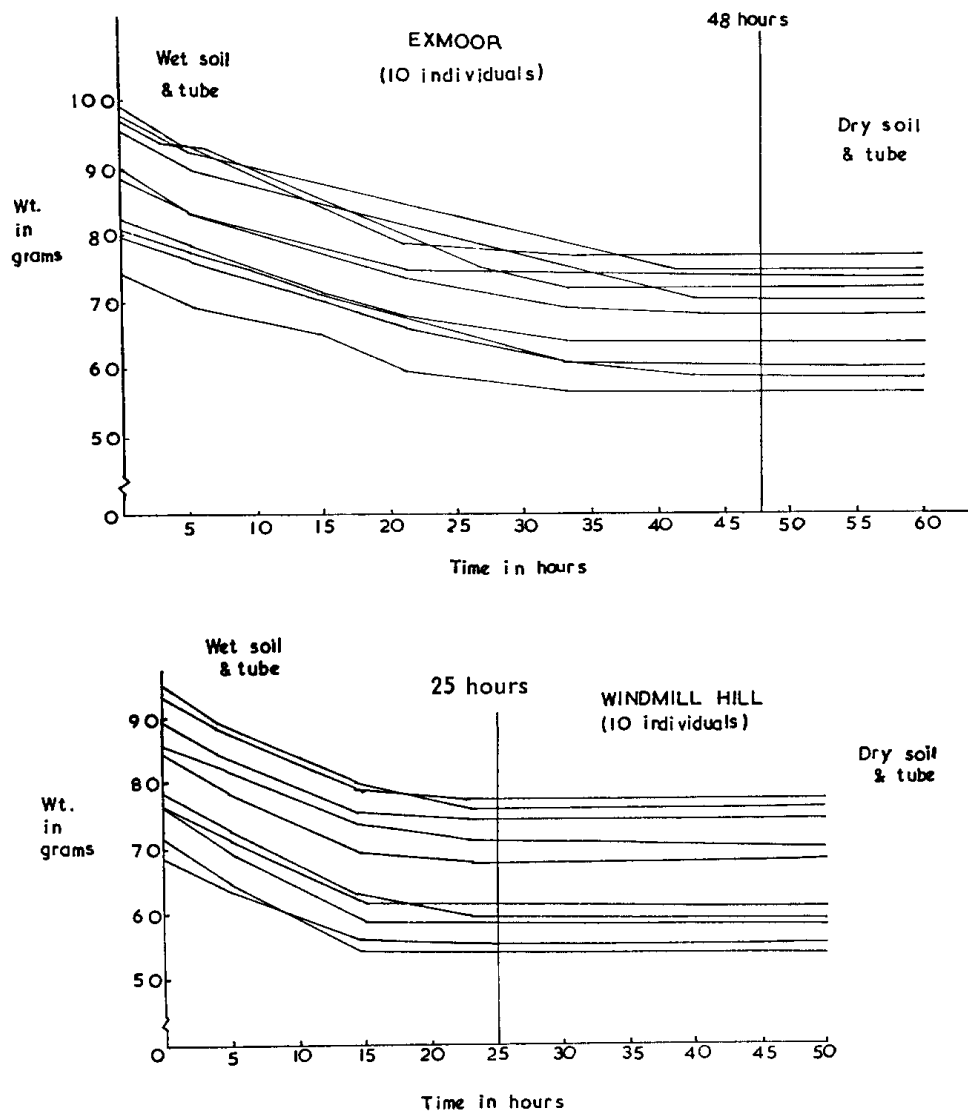


Fig. 1. The rate of drying of two soil moisture samples.

If a small sample is used with a very stony soil then the extreme situation might arise where one stone made up the total sample. Also it is apparent that the larger the mass of soil, then the fewer samples that can be collected because of cost.

The required sample size figures at the various standard errors in Table 3 suggest that there is very little difference in the precision with which the mean can be estimated by the four different soil masses. d^1 implies that more individuals would be required to estimate the mean than for the other categories, but this increased variability is largely the result of insufficient oven-drying (mentioned above); the figures for d^2 support this. It is possible

TABLE 3
The influence of size or mass of sample on soil moisture results

Soil reference	Container Size	Mean moisture ¹ content	Best estimate of standard deviation	Required sample size ² at given standard errors		
				5	2.5	1
1. Coombe Dingle A	a	42.5	5.01	4	6	25
	b	44.1	5.08	4	6	26
	c	43.4	4.35	3	5	19
	d ¹	32.1	6.72	4	8	45
	d ²	—	—	—	—	—
2. Coombe Dingle B	a	53.2	3.13	3	4	12
	b	54.3	3.34	3	4	13
	c	55.0	2.67	3	4	9
	d ¹	46.3	9.43	6	14	89
	d ²	54.9	3.39	3	4	13
3. Coombe Dingle C	a	44.9	2.68	3	4	9
	b	46.7	2.42	3	3	8
	c	45.6	2.49	3	4	8
	d ¹	41.9	6.01	4	7	36
	d ²	44.9	4.55	3	6	21

¹ Each figure is a mean of 10 individuals ²To estimate the mean at 95 % probability level.

a = Specimen tube vol. 12 cc; approx. wt of wet soil held = 15/25 g.

b = Specimen tube vol. 24 cc; approx. wt of wet soil held = 35/45 g.

c = Specimen tube vol. 27 cc; approx. wt of wet soil held = 60/80 g.

d¹ = Jar (uncorrected) vol. 98 cc; approx. wt of wet soil held = 400/500 g.

d² = Jar (corrected i.e. longer drying period).

that variability would increase considerably on very stony soils where only a small mass of soil was sampled.

The author has adopted sample mass c, taken with the special coring auger described above. Most of the soil moisture data presented in the three parts of this paper are therefore based on 60–100 g samples. It is suggested that the many estimates of variability and required samples size are at least applicable to studies where the mass of soil sampled ranges from 15–500 g.

Discussion

The gravimetric method remains the only direct way of measuring soil moisture and is therefore indispensable for calibrating instruments used in the indirect methods. Its big advantage is that it requires relatively simple, inexpensive equipment, and once limited experience has been gained large areas can be sampled, with labour the main (but considerable) expense.

TABLE 4
Analysis of variance results

Soil reference	Comparison of sample sizes	Level at which difference is significant	
		0.05	0.01
1. Coombe Dingle A	a v b v c v d ¹	*	*
	a v b v c	—	—
2. Coombe Dingle B	a v b v c v d ¹	*	*
	a v b v c	—	—
	a v b v c v d ²	—	—
3. Coombe Dingle C	a v b v c v d ²	—	—

* Significant difference.

— No significant difference.

The main disadvantages of the gravimetric method are that it requires a great deal of physical effort and time, to collect and dry the samples, and calculate moisture percentage. Cleaning, re-marking and general care of containers, even with the aid of a motor driven bristle brush, can take almost as long as sample collection (although the use of aluminium foil, and a simple computer programme to calculate moisture %'s and a whole range of statistical data, overcome some of these drawbacks). Also there is a delay of at least 24 hours in obtaining the results although this can be speeded by using infra-red drying (Popov²⁴)).

The most significant disadvantage is that repeated sampling destroys the experimental area. If a long term project is being undertaken then very careful planning is necessary to prevent too dense a network of sample sites, which may alter the hydrological conditions of the site. Eastwell²³) mentions this problem in connection with instrumental calibration and Cope and Trickett⁹) emphasise that "damage to plant roots and the introduction of variable drainage and infiltration characteristics may be unavoidable".

Therefore the author has taken the additional precaution of returning samples to sample holes to prevent, or lessen these artificial changes²⁵).

A critical factor, understressed in the literature, is that no two samples can be taken from exactly the same spot.

Therefore the gravimetric method itself accounts for some of the variability found in soil moisture distribution and may indeed account for supposedly significant changes in soil moisture in time and space... "The results obtained by the gravimetric method are affected by the stoniness, organic matter content, etc. of each sample. It is possible that the technique will indicate differences in moisture content from point to point in a heterogeneous

body even though the moisture content throughout the body is in equilibrium in terms of moisture gradients within the soil”²⁵).

The extreme case can be demonstrated where attempts are made to compare the moisture contents of sites with markedly different soils. If units of water were added to a constant soil volume of peat or humose loam, a loam or silty clay, and a coarse stony loam, it is possible to predict the relative weight basis moisture values likely to result according to the formula, moisture % (weight basis) = $(n/x) \times 100$, when x = weight of oven dry soil and n = the weight of water in the sample. With the peat or the humose loam, the high organic matter content means that x will be very low and therefore moisture content will be high; a large number of stones in the soil (normally this markedly decreases the moisture holding capacity of the soil) means that the weight of the oven dry soil is greatly increased resulting in a low moisture content value. Weight basis moisture figures must be accepted as one particular scale of wetness but must not be confused with another scale of wetness, for example one based on the feel of the soil. Some of these problems are illustrated in Table 5. The Long Knoll soils (1 and 2) containing much organic

TABLE 5
The influence of major soil differences on soil moisture results

Soil references	Weight % basis ¹	Vol. % basis	Weight of moisture (water) (g)
1. Long Knoll A	127.5	57.0	28.7
2. Long Knoll B	132.6	56.6	30.6
3. Windmill Hill A	65.6	51.4	26.0
4. Windmill Hill B	63.0	52.2	26.9
5. Exmoor A	79.3	55.2	29.3
6. Exmoor B	81.0	53.9	30.0
Soil references	Weight % basis	Weight % basis Corrected for stones	Weight of moisture corrected for stones
7. Exmoor C	74.7	91.3	25.7
8. Exmoor D	85.4	104.0	28.9

¹ Each figure is the mean of 10 individuals; also the assumption is made that an equal volume of soil was collected for each individual.

matter give the highest weight basis moisture values. The Exmoor soils (5 and 6) are “wetter” than those from Windmill Hill (3 and 4) because as well as containing many stones the former also have higher organic matter values. However, the increase in soil moisture content when a correction

for stone content was applied to another set of Exmoor samples is illustrated with 7 and 8. The same order is apparent in the volume basis figures – the volume method decreases the magnitude of values but similar differences can still be observed. Most interesting is a comparison of the soil moisture percentages on either basis, with the actual weight of water in samples. Thus for example, 1 contains less water than 5 yet its moisture percentages on both a weight and volume basis are higher; also, 4 and 6 are very similar on a volume basis, yet the respective water contents and the weight basis values are very different.

When quoting soil moisture figures, few writers mention the degree of heterogeneity and the type of soil from which the samples were taken, e.g. Stoeckeler and Curtis¹). Even where these are mentioned, the possible influence of high organic matter contents or very stony profiles on soil moisture values is not investigated, differences being accepted as actual moisture differences, e.g. Dreibelbis and Post²⁶); “It was noted that some of these locations showed a consistent deviation on the minus side from the average, indicating that these sampling locations are drier than the average for the watershed. Likewise, some of the locations were consistently higher in moisture content than the average...”

Probably these are exceptional cases, and the general conclusion can be made that it is unwise to attempt to compare or contrast soil moisture conditions at sites with very different soils.

However if we extend the ideas that have been outlined above to comparisons made between soils with only slight compositional differences, then the problem arises of distinguishing between two possibilities:

- a) apparently significant differences or similarities in moisture content could be the result of compositional influences on the gravimetric moisture calculation procedure.
- b) slight soil compositional changes such as variations in organic matter content may cause a significant increase in the moisture holding capacity of the soil and the actual moisture content.

Data summarized in Table 6 is used below to illustrate b) and a) respectively. The moisture percentage data for Windmill Hill suggest that the N. side of the hill is wetter than the south side. Is this a real difference in moisture content or an apparent difference due to the higher soil organic matter content of the north facing slopes? The weight of water figures confirm that the difference is a real one. There is little apparent difference between soil moisture percentages for the three Exmoor plots before stone correction. This is mainly the result of more stones in plots A and C than in B. When these are removed, plots A and C have considerably higher moisture percentages than B.

TABLE 6
The influence of minor soil differences on soil moisture results*

Soil references	Aspect	Slope	Soil volume in cc	Soil moisture % weight basis	Soil moisture % volume basis	Weight of moisture	Organic matter content
Windmill Hill A	South	10½°	46.7	52.1	44.6	20.8	12.4
Windmill Hill B	South	13½°	48.1	56.3	46.7	22.3	10.8
Windmill Hill C	North	11°	43.3	63.0	53.8	23.3	14.1
Windmill Hill D	North	11°	50.0	64.8	54.6	27.3	13.2
Soil references	Aspect	Slope	Soil moisture % weight basis before stone correction	Weight of moisture before stone correction	Soil moisture % weight basis After stone correction	Weight of moisture after stone correction	
Exmoor A	South	31°	44.3	19.7	66.7	19.2	
Exmoor B	South	26½°	43.9	17.4	63.7	16.9	
Exmoor C	South	37½°	44.8	21.2	67.2	20.8	

* Each figure is the mean of 10 individuals.

Although the volume basis method is probably the better one to use in theory (Burger²⁷), in practice, sampling conditions are often such that it is very difficult to obtain undisturbed cores of similar or measurable dimensions from contrasting areas and the weight basis method has to be used.

Conclusions

The problems outlined above cannot be ignored even if another method is being used, because of the general use of this technique for calibration purposes. If mistakes are made with the calibration procedure then spurious soil moisture values may result from even the most sophisticated and elaborate pieces of equipment. A number of recommendations can be made:

- (1) If more than one auger is to be used in a sampling programme, it is suggested that all augers be of the same type, or an additional source of error might be introduced. The type of auger used should be mentioned when reporting soil moisture results. If moisture contents were expressed on a stone free basis (*i.e.* as moisture % in fine soil, less than 2 mm Reinhart²⁸) then these precautions might become unnecessary.
- (2) In the temperature range 8–18 °C, container moisture losses are virtually nil for the first 24 hr after sampling. Even after 7 days, the greatest loss was only about 1% by weight. Aluminium foil is only slightly less efficient than corked and corked-vaselined glass tubes as a container in soil moisture determinations, as well as being much cheaper and more easily transported.
- (3) Because of vary different soil drying rates it is suggested that for different soil types simple tests be carried out to establish the times after which negligible losses occur for further periods of drying.
- (4) In most field studies a sample of about 50–100 g of soil is adequate.
- (5) As the gravimetric method itself may account for some of the variability found in soil moisture distribution, care is needed in interpreting the results.

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