Accelerating Soil Moisture Determination with Microwave Oven

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ABSTRACT Soils moisture content determined by using convection oven or stove. The aims of this study were to determine the exactness and the soil drying duration of the microwave oven. The convection oven was considered to make the right moisture content and was, hence, utilized as a source for assessing the results. The experimental design was factorial based on completely randomized design. Treatments were; air drying oven as control (105 °C for 24 hours) and a microwave oven (90-180-360-600 and 900 Watt in 5 and 10 min duration). Taking into data evaluations of the outcomes, the microwave oven was an affordable means of fast drying soils. The methods developed and applied for drying soils with a microwave oven were timely, efficient, precise, and safe. The standard microwave oven was the most practical device to use in drying soils. The article examined the methods in determining the moisture content in soils via microwave radiation, which greatly accelerated the procedure, simplify the complexity and expense of lab tests. The utilization of microwave ovens in 600-watts to dry soil samples to conduct soil moisture tests offers the potential for the results to be accessed in 10 minutes, contrasted with around 24 hours to acquire the same results employing the standard oven technique that is the standard strategy used as a part of the industry.

Key Words: Soil sample, moisture content, convection oven

Introduction

Traditionally in the soil moisture content testing, the standard oven drying technique is the most regularly utilized. Other instruments that are considered for use are the microwave oven drying and the hot plate techniques. There are still various inquiries over the exactness and the reasonableness of the last two techniques for applying in moisture content testing. From past studies the hot plate technique appears to be quite inaccurate when contrasted with the standard oven test technique and as such was not considered in this anticipate (Cormick, 2015).

Several studies over many years have demonstrated that there is a considerable of the potential for utilizing the microwave oven drying method to create quick and precise results and numerous organizations have developed assessment methods for using microwave ovens drying. Nevertheless, questions still remain about particular concerns in regards to the appropriateness of the microwave oven techniques (Cormick, 2015).

One of the key issues in utilizing a oven is around 24 hours time required for the drying of the soil. This can be different with sample types and sizes, however 24 hours is readily admitted as a standard drying time. The traditional convection oven method is fundamentally on a temperature of either 45ºC ± 5ºC or 105ºC ± 5ºC depending on the kinds of soil samples tested. It requires a long drying time of at least 20 hours. Hence, a quick but reasonably accurate recognition of moisture content of soils is required (Chung & Ho, 2008).

The time taken for the samples to dry using the microwave technique to be finished in around 20-40 minutes given the consequences of past studies (Cormick, 2015). As pointed out in a previous studies the detection of moisture content in a substance which include soil and sand from microwave measurement has been proven to be accurate and gives reliable results (Kress-Rogers and Kent, 1987; Oh et al., 1988).

There are credible explanations that microwave ovens are a feasible way and satisfactory alternate tool based on exactness, test duration, and advantages to cost evaluation (Kevin, 2002).

One aspect of microwave oven drying is to find relationship between the outcomes attained from the microwave technique and those achieved from the standard oven method. Literature and regulatory document reviews uncovered variable techniques for measuring soil moisture (Mendoza and Orozco, 1999; Gaspard, 2002). It is now well established that, the soil moisture content plays a significant role in irrigation time and also water consumption in farm, thus a new technique for quickly (less than 20 minutes) determining soil moisture content is required.

The specific objective of this research is, to develop a technique for rapidly and precisely determining soil moisture content. This is achieved by evaluating the precision and testing durations of drying soils with the standard microwave oven, and convection oven.

Materials and Methods

Fifty soil samples were randomly selected from different parts of the farm of Urmia University in 2015. All of the samples were taken roughly 0.5 m to 1.0 m depth from the ground surface. Compactly tied plastic bags were utilized after which the samples were placed into polystyrene box to avoid moisture loss, and then delivered to the laboratory for further analysis. After mixing, divided into two main samples. One sample passed through a 2 mm lab wiry sieve and unsieved. Physicochemical characteristics of soil sample were shown in Table 1.

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Table 1 Physicochemical characteristics of soil

EC (dS/m)	pH	O.C (%)	N (%)	P (mg/kg)	K (mg/kg)	Clay (%)	Silt (%)	Sand (%)	Soil Texture
0.54	7.21	0.94	0.094	7.6	395	32	37	31	Clay loam

50g of sieved and unsieved soil samples were measured using precision balance and put inside the weighed petri dishes and to each of them 10cc twice distilled water were added using a pipette. After soil sample preparations, the devices utilized are listed as follows:

Convection Oven: The convection oven used was IRAN KHODSAZ, Model: OD, 400

Standard Microwave Oven: The standard microwave oven used was a Solar Dom LG Model NO: CP-3493SCR.

The oven was checked and calibrated as required by the laboratory prerequisites. The oven was utilized just at the standard temperature of 105˚C +/- 5 ˚C as necessity of the Australian Standards (Standards Australia 2005) (Cormick, 2015).

Two of the prepared samples, as described above were incubated in the oven (105 ˚C) as control for 24 hours. Afterwards, soil dry weight recorded Two of the prepared soil samples also were placed inside microwave oven in different thermal power (90-180-360-600 and 900 Watt) at 5 and 10 min duration, Then, after the termination of the aforementioned time the soil samples was weighed. In conformity with Australian Standards, the sample was required to be permitted to cool after every heating cycle. A one-minute cooling period was planned for each sample after each heating cycle to eliminate any inconsistency in results because of various cooling (Cormick, 2015).

The experimental design was factorial based on completely randomized design. In fact, a comparison of drying effectiveness was made between a forced air drying oven (105 °C for 24 hours) and a microwave oven (90-180-360-600 and 900 Watt in 5 and 10 min duration) on 50 g of soils.

Analysis of variance was done by using the general linear model procedure in the statistical analysis system (SAS Institute, 2003). Means were separated using Duncan test at the 95% level of probability.

Results and Discussion

The results showed that the short drying period (10 min) in the microwave oven in 600 watts could effectively substitute for drying in a forced air electric oven at 105 °C for 24 hours. Table 2 and Table 3 demonstrate the mean of square and mean soil weight (g) changes with microwave and oven drying technique. Neither reported any challenges or difficulties from using the microwave oven to dry soils (Gaspard, 2002). In general, the microwave oven drying method delivered results that were very close the results generated by the standard oven technique utilizing. Indeed, the microwave oven system produced results in a significantly faster time period, which present a noteworthy advantage when rapid test outcomes are required (Gaspard, 2002).

The second revised edition of the standard soil test technique was issued in 2000 by the American Society for Testing and Materials (ASTM) (ASTM, 2000). The insignificant change was observed in the test procedures; however, the use of microwave ovens with powers of approximately 700 W was suggested (ASTM, 2000).

Kramarenko et al. (2016) found that the differences in the moisture content of peats acquired at microwave drying are not higher than in convection oven drying in most cases. Kumar (1987) demonstrated that the results obtained from the microwave oven were the same as with the outcomes from the standard oven test. Another study by Daod (2012) also proved very close results between the two techniques (Microvwave and Oven). It was reported that the standard microwave oven is the most feasible approach and offers reliable outcomes for detecting soil moisture content with the least time (Suwandi et al., 2009; Gaspard, 2002; Suwandi et al. 2009).

The laboratory microwave has been utilized in studies for decades, and offers affordable, fast and low cost estimates of soil moisture. The microwave gives an ever-boosting energy supply, which means over-drying of soils can occur, resulting in extreme stated moisture contents (Berney et al., 2011).

Table 2 Mean squares for unsieved and sieved soils in different watt and time duration

Source of variation	DF	MS	
		Unsieved Soil	Sieved Soil
Watt	4	44.08**	58.61**
Time duration	1	23.47**	33.49**
Watt × Time duration	4	1.95**	2.56**
Error	20	0.3	0.12
CV (%)		1.06	0.67

* and **, Significant at 0.05 and 0.01 probability level, respectively.

Table 3 Comparing effects of Microwave method in different duration and watt with Oven method on soil moisture content

Watt	Time duration (Minute)	Unsieved Soil Weight (g)	Sieved Soil Weight (g)
90	5	56.73[a]	57.01[a]
	10	54.01[b]	53.76[c]
180	5	54.2[b]	56.03[b]
	10	51.39[c]	52.95[d]
360	5	51.62[c]	52.06[e]
	10	49.4[d]	49.26[fg]
600	5	49.53[d]	49.56[f]
	10	48.87[d]	**48.47[hi]**
900	5	49.15[d]	48.8[gh]
	10	48.72[d]	48.45[hi]
Oven (Control)	24 hours	48.73[d]	**47.96[i]**

* Oven temperature: 105˚C. The same letters in each column show non- significant difference at P≤0.05 by Duncan test

Conclusion

In this research, the microwave oven has been found totally reasonable for soil moisture determinations. To improve the reliability of the technique, we modified the procedures, and the microwave oven values were calibrated against outputs acquired by utilize of conventional oven technique. The study affirmed that household microwave ovens are an efficient tool for fast moisture content determination of soils, as the testing is conducted in a short time, and the acquired data are as precise as in applying the drying ovens. These findings provide the following insight for future research that a variety of soils should be selected to make available a spectrum of behaviors necessary to validate moisture content response. To sum up, microwave oven method is the most feasible method and gives reliable results for determining soil moisture content with the shortest time.

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