Determining Particle Density in Dairy Manure Compost

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ABSTRACT

To accurately determine the bulk density of composted products, particle density must be precisely quantified. A submersion technique developed for use in soil science was adapted by utilizing hexane (a low density solvent) to facilitate particle submersion. Two composts were subjected to multiple treatments to determine the precision of the method. The inexpensive methods produced repeatable results that will aid compost producers in quantifying their products.

Keywords: compost, particle density, dairy manure

INTRODUCTION

It has been widely accepted that compost provides chemical and physical benefits to soils. Although compost products vary and must be carefully tested to determine their exact nature, numerous laboratory trials with different products have successfully quantified the beneficial effects (Cornell University Composting 2003).

As compost use increases, source materials and the quality of the final product have become more regulated by federal, state and local agencies. Once considered an inexact science, quantifying the physical, chemical and biological properties of compost has become more exact. In 2001, the U.S. Composting Council (USCC) and United States Department of Agriculture (USDA) jointly produced *Test Methods for the Examination of Composting and Compost (TMECC)* to establish standards for precise methodologies to be used in compost analysis and to address many of the variable characteristics of compost. While the TMECC guidelines specifically address bulk density and air capacity, they do not specify a procedure for determining the particle density of composted solids (Thompson 2001). The Texas Department of Transportation (TxDOT) and the Texas Commission for Environmental Quality (TCEQ) have recently set forth new specifications for compost used on large state or federally-funded projects within Texas. Under the new specification, compost suppliers must comply with the USCC Seal of Testing Assurance (STA) program, which mandates a variable compost testing frequency based on the tonnage generated annually by each individual producer.

As such, the accurate quantification of particle density (as a component of bulk density) is vitally important for gravimetric compost measurements. For other media such as soil, particle density is often assumed to be 2.65 g/cm^3, the density of quartz (Brady and Weil 2002). However, compost particle density is more inconsistent due to variation in source materials.

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Concisely stated, the method employs the submersion of a known mass of compost in hexane to determine the volume of the compost solids (Figure 1). While hexane was used because of its low density (0.66 g/cm^3), the premise of the method remains valid for many other low density liquids. The use of a low density liquid causes particles that are normally buoyant in water to sink, facilitating an accurate measurement of the compost solids volume.

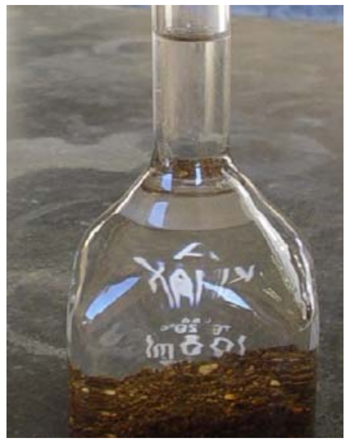

Figure 1. Compost submerged in hexane.

The goal of this project was to test this approach for the estimation of compost particle density and to determine the precision of the method across variable products.

MATERIALS AND METHODS

The physical properties of compost are similar to those of highly organic soils. As such, the method described below is adapted from Blake and Hartge (1986), a commonly employed method of determining soil particle density. Simply defined, density is the mass per unit volume of a given substance and is typically reported as grams per cubic centimeter (g/cm^3) or kilograms per cubic meter (kg/m^3) (Hillel 1998). While bulk density assesses the solid, liquid, and gaseous components of a material, particle density only addresses the solids. The key difference between the methodology employed by Blake and Hartge and that proposed for compost concerns the liquid for submergence. While soil particles, with particle densities commonly in excess of 1.0 g/cm^3, are easily submerged in distilled water, many compost particles are somewhat buoyant and as a result will not settle out of suspension so that an accurate measurement of displaced volume can be determined. Given this, hexane was selected as an inexpensive, low density liquid that allows for compost particle settling.

For this study, diary compost was collected from two locations in Erath County, Texas. The mass and volume of compost solids were quantified independently using the same sample. Prior to analysis, compost was oven dried at 70°C for 48 hours to remove moisture. Dried samples were ground to reduce the size of large aggregates. Next, 10-20 g of compost was placed in a 100 ml volumetric flask and weighed on a Mettler AE200 top loading balance to an accuracy of ±0.0001 g. To displace gases from the compost sample, the flask was brought to volume with hexane, completely submersing the compost. While tilted at an angle, the flask was gently swirled (Figure 2).

Figure 2. Agitating compost via swirling in a square based flask.

Square-based flasks appeared to be most efficient at agitating the submerged compost. After mixing, the flask was again brought to volume with hexane and the weight of the compost/hexane mixture was recorded. Samples from both locations were independently tested fifteen times using the aforementioned method. Compost particle density was calculated using equation 1:

$$\rho_p = \rho_h (W_c) / [W_c - (W_{ch} - W_h)] \quad \text{Eq. 1}$$

where
ρ_p = Compost density (g/cm^3),
ρ_h = Density of hexane (g/cm^3),
W_c = Weight of oven-dried compost (g),
W_{ch} = Weight of compost and hexane (g),
W_h = Weight of 100 ml of pure hexane (g).

RESULTS AND DISCUSSION

As expected, the particle density of both compost samples was less than the assumed particle density of soil. Particle density of Compost A ranged from 2.22 g/cm^3 to 2.39 g/cm^3 with an average of 2.31 g/cm^3 and a standard deviation of 0.0475 (Table 1). Particle density of Compost B ranged from 2.19 g/cm^3 to 2.32 g/cm^3 with an average of 2.27 g/cm^3 and a standard deviation of 0.0364 (Table 1). It should be noted that the obtained values are somewhat higher than expected, but can likely be tied to the presence of carbonates and other inorganic media such as soil particles contained within the compost samples. Such carbonates and inorganic compounds are often inadvertently incorporated into compost through mechanical operations such as scraping of the soil surface during mixing or aeration processes and through eolian deposition of mineral soil.

Table 1. Particle density of two dairy manure composts from Erath County, TX.

Replication	Compost A	Compost B
	---------------------g/cm3------------------	
1	2.37	2.19
2	2.31	2.28
3	2.33	2.27
4	2.37	2.28
5	2.39	2.26
6	2.35	2.23
7	2.31	2.26
8	2.32	2.28
9	2.32	2.31
10	2.29	2.32
11	2.26	2.29
12	2.22	2.31
13	2.28	2.28
14	2.29	2.23
15	2.25	2.23
Mean	2.31	2.27
Std. Error	0.0123	0.0094

CONCLUSIONS

The hexane submersion method of compost particle density measurement offers an expeditious, accurate means of analysis. As a component of compost bulk density, the determination of compost particle density is vitally important in assessing the mass and/or volume of compost. Such information is germane not only to regulatory issues, but production, shipment, storage, blending and application of composted products.

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