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Information

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Biological Resources Engineering ***FACTS***

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DETERMINING THE AMOUNT OF MANURE IN A PILE OR A POOL

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Planning for the most effective use of manure on your farm requires a combination of information that defines the quality and quantity of manure available. The manure analysis tells you the nutrient content of the manure in pounds per ton or pounds per gallon. A manure spreader calibration allows you to develop a manure application rate that matches the crop nutrient need with the manure nutrient content in terms of tons or gallons of manure per acre. An estimate of the total amount of manure in storage allows you to determine the total number of acres that can be fertilized at the calibration rate.

The determination of the amount of manure available for spreading requires estimation of the volume in a pile or container. This fact sheet describes methods of measurement and calculation of volume and the conversion of volume to weight.

What is volume?

Volume is the amount of space contained within or occupied by an object. Volume is measured in cubic units such as cubic feet, cubic inches, cubic meters or cubic yards. With simple straight sided right angled boxes (Figure 1), the calculation of volume (**V**) is simply the width (**W**) multiplied by the height (**H**) multiplied by the length (**L**) of the space (**V = H x W x L**).

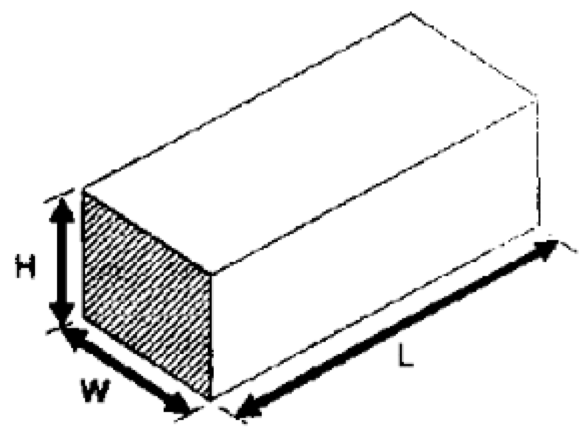


Figure 1. Volume of a simple box.

Volume can also be considered as the area (width multiplied by height) of the end of a uniform object multiplied by its length. In Figure 1, the end area (**A**) can be **W x H** and the volume (**V**) is then **A x L**. With the end area we can develop the volume of objects more complex than a simple box. Formulas for computing the volume of uniform shapes are shown in Appendix A.

Use consistent measurement units

Measured dimensions for computing volume must all be in the same units. For example, a length measured as 5 feet - 6 inches must be written as 5 1/2 feet or 5.5 feet or 66 inches but not as a combination of feet and inches. All measurements must have the same units. If you measure height in inches then you must measure both length and width in inches and the volume will be calculated as cubic inches. Unit conversions are shown in Table 1.

Unit 1	Factor	Unit 2
LENGTH		
foot	12	inches
	0.3048	meters
	0.333	yards
	30.48	centimeters
inch	2.54	centimeters
mile	5,280	feet
	1,760	yards
	1,609	meters
AREA		
acre	43,560	square feet
	4,860	square yards
	4,047	square meters
	0.4047	hectare
square foot	144	square inches
	0.0929	square meters
square inch	6.45	square centimeters
	645	square millimeters
square mile	2.59	square kilometers
square yards	9	square feet
	1,296	square inches
	0.8361	square meters
VOLUME		
acre-foot	12	acre-inches
	43,560	cubic feet
	325,848	gallons
acre-inch	102.8	cubic meters
	3,621	cubic feet
	27,154	gallons
bushel	1.25	cubic feet
	0.035	cubic meters
cubic feet	7.5	gallons
	0.028	cubic meters
	1,728	cubic inches
cubic inch	0.016	liters
	16.39	cubic centimeters
cubic yard	0.7646	cubic meters
	27	cubic feet
gallon	3.79	liters
WEIGHT		
pounds	0.454	kilograms

Unit 1 multiplied by factor equals Unit 2.
5 gallons times 3.79 equals 18.95 liters

Unit 2 divided by factor equals Unit 1.
50 cubic feet divided by 27 equals 1.85 cubic yards.

Table 1. Unit conversions

Computing volume of piles

Volumes of complex shapes must be computed by breaking the complex shape into an imaginary group of simple shapes. The volume of each simple shape is computed and when all the simple volumes are added together the result is a good estimate of the complex shape. Several examples are shown in Figure 2. For example, a manure tank with an annex becomes two rectangular prisms; a heaped load on a wagon becomes a rectangular prism and a rectangular pyramid.

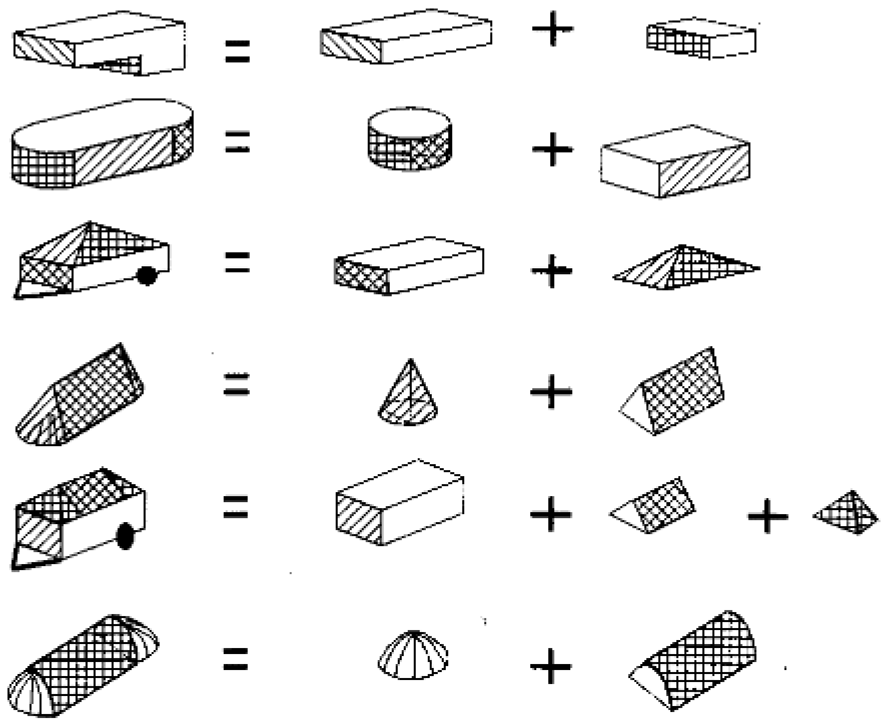


Figure 2. Breaking complex shapes.

Where prism ends are not parallel or where a dimension is not uniform along a shape estimate an average for the dimension and use the average in the calculations. In Figure 3 the height of the left shape is the average of the four corner heights. The top length of the right shape is the average of the two edge lengths.

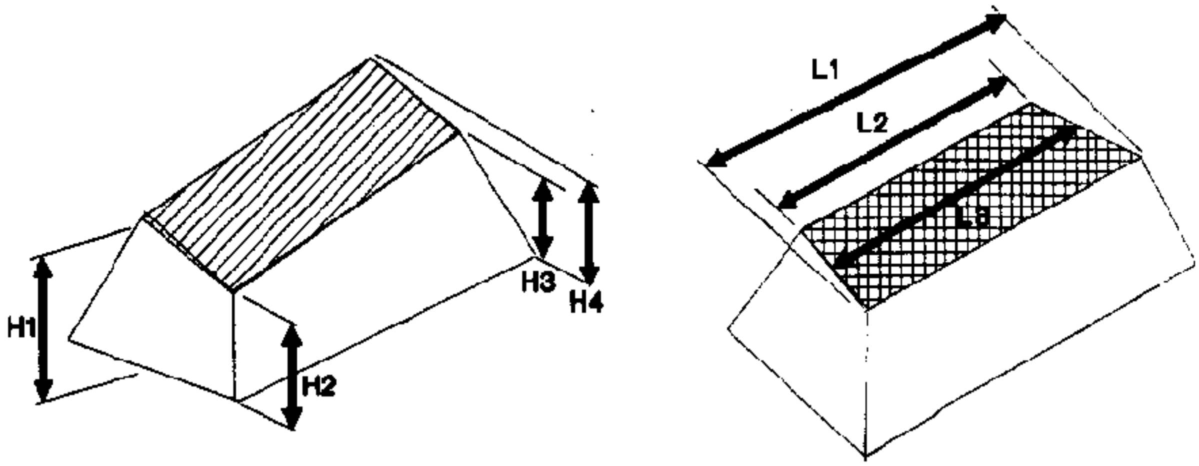


Figure 3. Averaging unequal sides.

Manure piles usually do not have straight geometric sides. Although imaginary uniform shapes can be broken out of the total shape there is always some odd shape left over. In these cases it becomes necessary to imagine moving manure around to form a measurable shape. Then estimate the dimensions of the imaginary shape for use in the calculations. Of course, the estimate of volume becomes less accurate as more imagination is required.

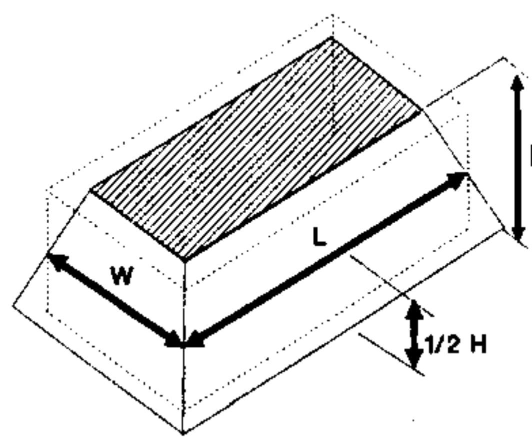


Figure 4. Making a pile into a box.

A pile can be turned into a box by imagining the sides vertical. Do this by placing a flag at a point one half the height of the pile at each corner. The distance measured between the flags represents the length and width of the box. Develop an average width or length if the opposite sides are not of similar dimension. Measure an average height using the actual height of the pile. The imaginary box is now the average of the width by the average of the length by the average of the height as shown in Figure 4. A similar approach can be used with nearly circular piles to form a cylinder. This method provides a good estimation that is usually slightly less than the amount actually in the pile.

Ponds and basins

Ponds and in-ground manure basins can be considered as inverted piles (Figure 5) and volume can be computed using the same estimating procedures as used for piles. Some in-ground manure storage basins are too complex to be readily broken into simple shapes and alternative methods for estimating volume may be necessary.

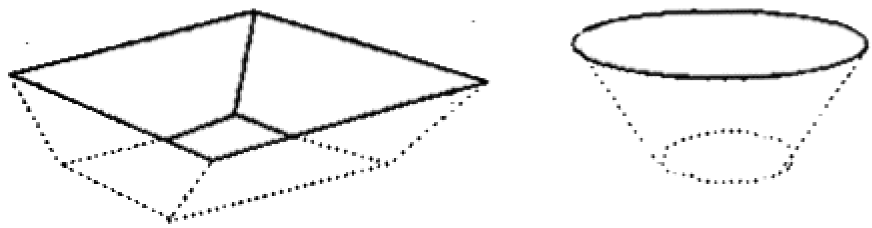


Figure 5. Basins are inverted piles.

Volumes may have been computed during the design of the basin and, assuming construction closely followed the design, reviewing the design data may provide a good estimate of volume.

Volume can also be estimated by measuring the amount of manure removed from the basin. Simply count the number of loads removed and measure the amount in an average load. With highly liquid waste the storage basin can be calibrated by measuring the number of loads removed between different depths. A pole marked as a depth gauge can then be erected within the basin and used to indicate the volume of storage or number of spreader loads available at any level.

Converting volume to field application units

Manure application to cropland is usually specified as so many gallons or tons per acre. Yet, the volume computed for the basin, pile or spreader is usually in units of cubic feet and sometimes as gallons. This situation requires further computation to convert the units of estimated volume into units of application.

Converting volume to gallons can be accomplished using the relations given in Table 1. For example, if we estimated the volume of a manure basin at 5,000 cubic feet then the conversion to gallons would be: 5,000 x 7.5 = 37,500 gallons (cubic feet multiplied by 7.5 equals gallons from Table 1).

Converting manure volume to weight requires additional measurement and computation to determine the weight of manure in a unit of volume (bulk density). The conversion of total volume to total weight is then computed by multiplying the volume by the bulk density. For example, if the average bulk density of the manure was 50 pounds per cubic foot of volume then the total weight of 5,000 cubic feet of manure volume would be: 5,000 x 50 = 250,000 pounds or 125 tons.

Determining bulk density

Bulk density is determined simply by multiplying a unit volume of the manure and dividing the weight by the volume. Although any volume can be used, a 5-gallon plastic bucket is very convenient. From Table 1, a 5-gallon bucket contains 0.667 cubic feet (5 gallons/7.5 = 0.667).

As an example, if a 5-gallon bucket weighed 1 pound when empty and 30 pounds when filled with manure then the weight of the manure would be 30 - 1 = 29 pounds. The bulk density would be the manure weight divided by the bucket volume or 29 pounds/0.667 cubic feet = 43.5 pounds/cubic foot.

The bulk density of manure depends on how much water, solids and air it contains. A volume of wet manure pack weighs considerably more than an equal volume of dry manure. In preparing a volume of manure for weighing to determining bulk density it is important to fill all the space in the bucket and to pack the manure to the same degree as exists in the pile, basin or spreader that is being measured.

The density of manure stored in a pile or basin may not be uniform throughout. Some areas may contain more bedding or more water than others. Bulk density should be determined from areas that best represent the majority of the manure. The average of several bulk density measurements from different areas is recommended.

Summary

Determining the amount of manure available for land application is an important part of manure nutrient management. Estimating the volume of a pile or basin of manure requires imaginative manipulation of lines and complex shapes to develop shapes adaptable to simplified equations. Manure applications specified by weight require a further estimation of manure bulk density. Bulk density is the weight per unit volume of the manure as it exists in the storage pile or basin. Bulk density can be estimated by weighing a know volume of the manure.

Appendix A. Formulas for Volume Computation

A = area V = volume

$A = W \times H \div 2$
$V = A \times L$

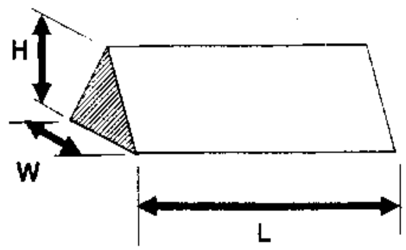


Figure a. Triangular prism.

$A = H \times (Wt + Wb) \div 2$
$V = A \times L$

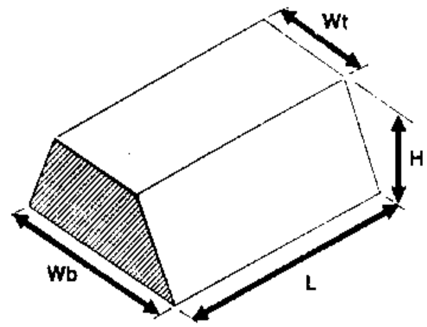


Figure b. Trapezoid prism.

$A = 0.785 \times D \times D$
$V = A \times L$

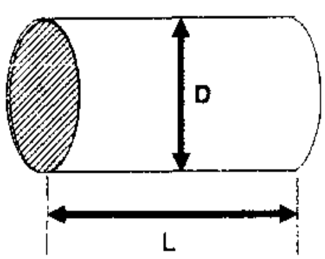


Figure c. Circular prism.

$A = 0.7 \times H \times W$ (approximate)
$V = A \times L$

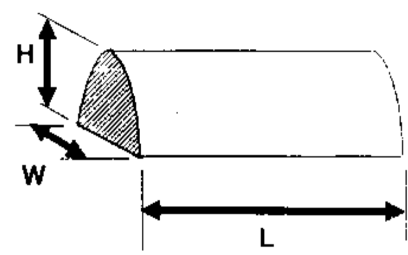


Figure d. Circular segment prism.

$A = W \times L$
$V = A \times H \div 3$

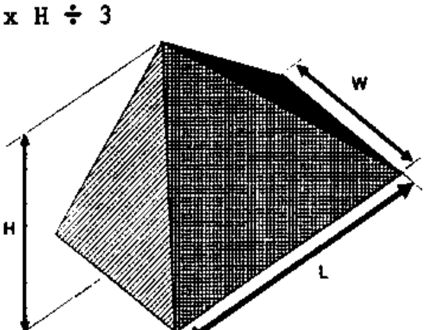
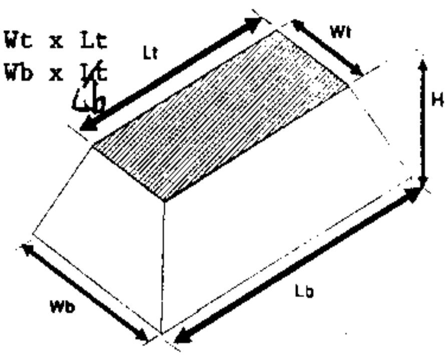


Figure e. Pyramid.

$At = Wt \times Lt$
$Ab = Wb \times \cancel{Lt}$ Lb



$V = H \times (Ab + At + \sqrt{Ab \times At}\ ) \div 3$

Figure f. Frustum of pyramid.

Appendix A (cont.). Formulas for Volume Computation

A = area   V = volume

$A = B \times W \div 2$
$V = A \times H \div 3$

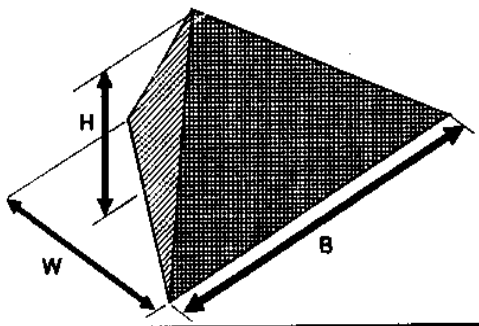
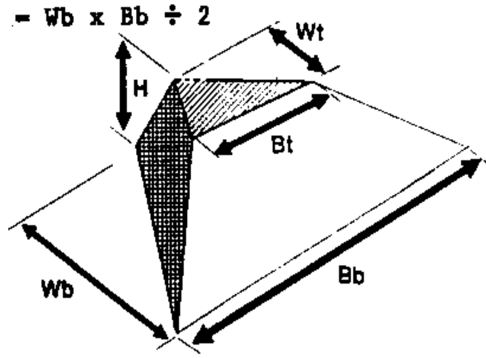


Figure g. Triangular pyramid

$At = Wt \times Bt \div 2$
$Ab = Wb \times Bb \div 2$



$V = H \times (Ab + At + \sqrt{Ab \times At}\ ) \div 3$

Figure h. Frustum triangle pyramid

$A = 0.785 \times D \times D$
$V = A \times H \div 3$

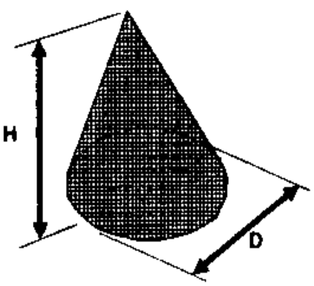
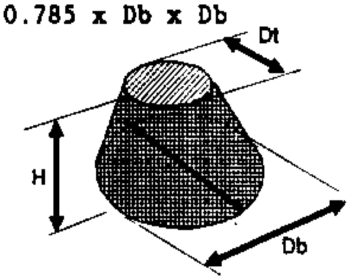


Figure i. Cone.

$At = 0.785 \times Dt \times Dt$
$Ab = 0.785 \times Db \times Db$



$V = H \times (Ab + At + \sqrt{At \times Ab}\ ) \div 3$

Figure j. Frustum of a cone.

$V = 0.524 \times D \times D \times D$

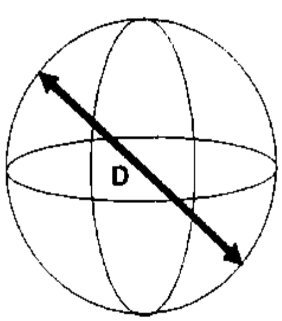
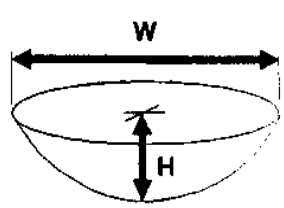


Figure k. Sphere.

$P = 3 \times W \times W$ $Q = 4 \times H \times H$



$V = 0.131 \times H \times (P + Q)$

Figure l. Spherical segment.