Experiments on Compost

- Porosity of Compost
- Water holding capacity of Compost
- Organic matter content of Compost
- Buffering capacity of Compost

by

Helicon

Experiments on Compost
Contents ‘Experiments on Compost’

What is the effect of compost on soil properties? ................................................................. 3
Introduction: .............................................................................................................................. 3

Experiment 1: Determination of the porosity of compost ....................................................... 5
Introduction: .............................................................................................................................. 5
What materials are needed? ......................................................................................................... 6
Preparation of samples ................................................................................................................ 6
Experiment per sample, step by step: ...................................................................................... 6
Table 1: Porosity measurements .............................................................................................. 7
Analysis of the results: .............................................................................................................. 8
Table 2: Porosity results ............................................................................................................ 8

Experiment 2: Determination of the ‘water holding capacity’ ................................................ 9
Introduction: .............................................................................................................................. 9
What materials are needed? ......................................................................................................... 9
Experiment, step by step: .......................................................................................................... 10
Table measuring results: .......................................................................................................... 10
Analysis of the results: .............................................................................................................. 11
Table calculated results ‘Water holding capacity’ ................................................................. 11

Experiment 3: Determination of the ‘organic matter content’ ............................................. 12
Introduction ............................................................................................................................. 12
What materials are needed? ....................................................................................................... 13
Experiment, step by step: Procedure with oven .................................................................... 14
Experiment, step by step: Procedure with Bunsen burner or hot plate ................................ 14
Table measuring results: .......................................................................................................... 14
Analysis of the results: .............................................................................................................. 15
Table calculated results ‘Organic matter content’ .............................................................. 16

Experiment 4: Determination of the ‘buffering capacity’ .................................................... 17
Introduction ............................................................................................................................. 17
What materials are needed? ....................................................................................................... 17
Experiment, step by step: .......................................................................................................... 18
Table buffer capacity results ................................................................................................. 19
Analysis of the results: .............................................................................................................. 19

Sources: .................................................................................................................................. 19
What is the effect of compost on soil properties?

Introduction:

Compost is well-known as a soil supplement or as organic material that is added to soil to improve its physical or chemical characteristics.

One of the characteristics of compost is that it enhances soil drainage. On the other hand it also has a positive effect on the ability of soil to hold water so that it is available to microorganisms and plant roots.

But is this true?

- Does compost make clay soils less compact and better drained?
- Do compost supplements make sandy soils better able to hold water?

To have an answer on these questions four experiments are described on the next pages. One of the experiments is to test compost and soil for porosity and water holding capacity.

Another experiment will guide you to measure organic matter content of compost and soil. This will lead to better understanding of comparing different types of compost and soil, or compost in various states of decomposition.

In most cases soils contain less than 20% organic matter. In compost this percentage of organic matter is much higher.
The final experiment, the so called ‘buffering capacity’, provides a simple test to measure what will happen to the chemistry of soil if a certain amount of compost is added to the soil. And also what will be the effect on the chemistry of the acidic water that percolates through it.
Experiment 1: Determination of the porosity of compost

Introduction:
By performing this experiment you will measure the volume of pore space in a compost or soil sample.

Porosity measures the proportion of a given volume of soil occupied by pores containing air and water.

It provides an indication of whether the soil is loose or compacted, which affects both drainage and aeration.

A sandy soil has large particles and large pore spaces whereas a clayey or silty soil has smaller pore spaces.

<table>
<thead>
<tr>
<th>SOIL TYPE</th>
<th>SOIL TEXTURE</th>
<th>SOIL COMPONENTS</th>
<th>INTAKE RATE</th>
<th>WATER RETENTION</th>
<th>DRAINAGE EROSION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sandy soil</td>
<td>Coarse texture</td>
<td>Sand, Loamy sand</td>
<td>Very high</td>
<td>Very low</td>
<td>Low, Good drainage</td>
</tr>
<tr>
<td>Loamy soil</td>
<td>Moderately coarse</td>
<td>Sandy loam, Fine loam</td>
<td>Moderately high</td>
<td>Moderately low</td>
<td>Low, Good drainage</td>
</tr>
<tr>
<td>Medium texture</td>
<td>Very fine loam, Loam, Silty loam, Silt</td>
<td>Medium</td>
<td>Moderately high</td>
<td>Moderately high</td>
<td>Moderate drainage</td>
</tr>
<tr>
<td>Moderately fine</td>
<td>Clay loam, Sandy clay loam, Silty clay loam</td>
<td>Moderately low</td>
<td>High</td>
<td>High</td>
<td>Moderate drainage</td>
</tr>
<tr>
<td>Clay soil</td>
<td>Fine texture</td>
<td>Sandy clay, Silty clay, Clay</td>
<td>Low</td>
<td>High</td>
<td>Drainage, Severe erosion</td>
</tr>
</tbody>
</table>

What may be surprising, though, is that the numerous small pores in the clayey or silty soil add up to a larger total pore volume than in a sandy soil.

In general, addition of organic matter such as compost increases a soil’s porosity.
What materials are needed?

- Plates, bowls or small containers
- Table spoon
- 100-mL graduated cylinder
- Stirring rod slightly longer than graduated cylinder
- Compost
- Sand (e.g. river sand)
- Optional: other soil samples

Preparation of samples
Standard test is with compost, sand and a mixture of these (1/1 by volume). Of course other soils and mixtures may be added.

Experiment per sample, step by step:

Step 1: Fill the graduated cylinder about half full with the sample
Step 2: Tap the cylinder firmly with your fingers several times to settle the sample
Step 3: Record the ‘Volume of packed sample’. Use the table on the next page to write down your results.
Step 4: Pour the sample out and save it to use in step 6.
Step 5: Fill the graduated cylinder to the 70-mL level with water.

(The unit of measurement is milliliter)
Step 6: Slowly add the sample from step 4.

Step 7: Stir with rod to break up clumps, then let stand for 5 minutes to allow bubbles to escape.

Step 8: Record the final ‘Volume of sample/water mixture’. Use the table below to write down your results.

Table 1: Porosity measurements

<table>
<thead>
<tr>
<th>sample</th>
<th>Volume of packed sample (mL)</th>
<th>Volume of sample/water mixture (mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Analysis of the results:

- Calculate the volume of solids in your tested samples:

\[ \text{Volume of solids (mL)} = \text{Volume of sample/water mixture} - 70 \text{ mL water} \] (mL)

- Calculate the total pore space volume:

\[ \text{Volume of pore space} = \text{Volume of packed sample} - \text{Volume of solids} \] (mL)

- Determine the porosity:

\[ \text{Porosity of sample} = \frac{\text{Volume of pore space (mL)}}{\text{Volume of packed sample (mL)}} \times 100\% \]

- Compare the porosity of compost, sand and compost-sand mixture (and optional other types of soil, with and without compost added)

Table 2: Porosity results

<table>
<thead>
<tr>
<th>Sample</th>
<th>Volume of solids (mL)</th>
<th>Volume of pore space (mL)</th>
<th>Porosity of Compost (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Experiment 2: Determination of the ‘water holding capacity’.

Introduction:
The water holding capacity of a soil determines its ability to sustain plant life during dry periods.

Water is held in the pores between soil particles and in the thin films surrounding particles. Different types of soil retain different amounts of water, depending on the particle size and the amount of organic matter.

Organic matter adds to a soil’s water holding capacity because humus particles absorb water.

The goal of this experiment is to determine the ability of a soil or compost to retain moisture against drainage due to the force of gravity.

What materials are needed?

- Funnel
- Piece of tubing to attach to bottom of funnel
- Clamp for tubing
- Ring stand with attachment to hold funnel
- Circular filter paper or coffee filter large enough to line funnel
- 100 mL of air-dried compost, soil, compost/soil mixture
- Balance with g accuracy
- 2x 250-mL beakers
- 100-mL graduated cylinder
- Stirring rod slightly longer than graduated cylinder
Experiment, step by step:

Step 1: Spread out and thoroughly air-dry the compost, compost/soil mixture, or soil samples (optional: dry the samples in a microwave or a 70 °C oven)

Step 2: Attach tubing to the bottom of the funnel and clamp it shut. Attach the funnel to the ring stand, suspended above the graduated cylinder.

Step 3: Line the funnel with filter paper or a coffee filter.

Step 4: Place 100 mL of air-dried compost or compost/soil mixture into the funnel.

Step 5: Using the graduated cylinder, measure 100 mL of water. Gradually pour enough water into the funnel to cover the compost sample. Record the amount of ‘Water Added’.

Step 6: Stir gently, then let sit until the sample is saturated.

Step 7: After the compost is saturated, release the clamp to allow excess water to flow into the graduated cylinder.

Step 8: After the dripping stops, record the amount of ‘Water Drained’ that is in the graduated cylinder.

Table measuring results:

<table>
<thead>
<tr>
<th>Sample name:</th>
<th>Recorded amount ‘Water Added’ (mL)</th>
<th>Recorded amount ‘Water Drained’ Volume of compost/water mixture’ (mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3: Measuring results ‘water holding capacity’ of compost
Analysis of the results:

- Calculate how much water was retained in the 100-ml sample of compost or soil

\[
\text{Water retained in 100mL compost or soil} = \text{water added} - \text{water drained} \quad (\text{mL})
\]

- Water holding capacity is expressed as the amount of water retained \textit{per liter} of soil, so the next step is to

- For this reason multiply by 10 to convert from the 100-ml sample to a full liter:

\[
\text{Water holding capacity} = 10 \times (\text{water retained in 100 mL compost or soil}) \quad (\text{mL/L})
\]

- Compare the water holding capacities of compost and various types of soil, with and without compost added.

Table calculated results ‘Water holding capacity’

<table>
<thead>
<tr>
<th>Sample name:</th>
<th>Water retained in 100mL compost or soil (mL)</th>
<th>Water holding capacity (mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\textit{Table 4: Calculated ‘water holding capacity’ per type of compost/soil}
Experiment 3: Determination of the ‘organic matter content’.

Introduction

When an oven-dry sample of soil or compost is heated to 500°C, organic matter is volatilized. These “volatile solids” make up the organic fraction of soil, including living biomass, decomposing plant and animal residues, and humus, the relatively stable end product of organic decomposition. The residue left after combustion is ash, composed of minerals such as calcium, magnesium, phosphorus, and potassium. In general, 50–80% of the dry weight of a compost represents organic matter that is lost during combustion.

Organic matter makes up a much lower percentage of the dry weight of soils. Most are less than 6% organic matter, with higher percentages occurring in bog soils. Surface soils have higher organic matter contents than subsoils because humus is formed through decomposition of accumulated residues of crops or natural vegetation.

The most productive soils are rich in organic matter, which enhances their capacity to hold both water and nutrients in the root zone where they are available to plants.

The goal of this experiment is to determine the organic and mineral fractions of a compost or soil sample.
What materials are needed?
- 10 g Sample of compost or soil
- Porcelain crucible
- Tongs
- Desiccator (optional)
- Laboratory oven, Bunsen burner, or hot plate

Example of a laboratory oven (left picture) and a Bunsen burner (right picture)

If a Bunsen burner or hot plate is used for combustion:
- Goggles
- Glass stirring rod
- Fan or other source of ventilation
Experiments on Compost

Experiment, step by step: Procedure with oven

**Step 1:** Weigh the porcelain crucible, then add about 10 g of compost or soil. Write this weight down in the table on the next page.

**Step 2:** Dry the sample for 24 hours in a 105°C oven.

**Step 3:** Cool in a desiccator (or a nonhumid location), and reweigh. Write this weight down in the table on the next page.

**Step 4:** Ignite the sample by placing it in a 500°C oven overnight. Using tongs, remove the crucible from the oven, and again place it in a desiccator or nonhumid location for cooling. Weigh the ash. A pottery kiln can be used if a laboratory oven is not available. Write this weight down in the table on the next page.

Experiment, step by step: Procedure with Bunsen burner or hot plate

**Step 1:** To avoid breathing the fumes, set up a fan or some other type of ventilation system.

**Step 2:** Wearing goggles, heat the sample gently for a few minutes, then gradually increase the heat until the crucible turns red.

**Step 3:** Stir the compost occasionally, and continue the combustion until the sample becomes light colored and you can no longer see vapors rising.

![The Bunsen Burner](image)

*Schematic overview of a Bunsen burner*
Table measuring results:

<table>
<thead>
<tr>
<th>Sample name:</th>
<th>Weight of porcelain crucible (g)</th>
<th>Weight of crucible plus dried sample (g)</th>
<th>Weight of crucible plus ash (g)</th>
<th>Weight of ash</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Table 5: Measuring results ‘organic matter content’ of compost*

Analysis of the results:

- Calculate the percentage of organic matter using the following equation:

\[
\text{Percentage of Organic matter} = \frac{W_d - W_a}{W_d} \times 100\%
\]

in which:
- \(W_d\) = dry weight of compost
- \(W_a\) = weight of ash after combustion

How does the organic matter content of your compost compare with that of the soils you tested?

Does the organic matter content diminish during the composting process, or does it just change in form and chemical composition?
If you divide the percentage of organic matter by 1.8 (a number derived through laboratory measurements), you can get an estimate of the percentage of carbon in your sample:

\[
\text{Carbon content} \ (\%) = \frac{\text{Organic Matter} \ (%)}{1.8}
\]

This may be useful if you know the C:N ratio and you want to figure out the percentage of nitrogen:

\[
\text{Nitrogen content} \ (\%) = \frac{\text{Carbon content} \ (%)}{\text{C:N}}
\]

**Table calculated results ‘Organic matter content’**

<table>
<thead>
<tr>
<th>Sample name:</th>
<th>Content ‘Organic matter’ (%)</th>
<th>Carbon content (%)</th>
<th>Nitrogen content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Table 6: Calculated ‘organic matter content’ per type of compost/soil*
Experiment 4: Determination of the ‘buffering capacity’

Introduction
Finished compost usually has a pH around neutral, in the range of 6–8. It also tends to have a high buffering capacity, meaning that it resists change in pH. Soils with high buffering capacities do not experience drastic pH fluctuations that may be detrimental to microbial life and plant growth.

Buffering capacity needs to be taken into account when determining the amounts of lime, sulfur, or other chemicals that are applied to soil to alter its pH. The buffering capacity of soil may be provided by either mineral or organic components.

Quartz sand has almost no buffering capacity, so even small additions of acid will drop the pH of the sand and its drainage water. In contrast, a sand made of crushed limestone is highly buffered because it contains calcium and magnesium carbonates.

The addition of organic matter such as compost tends to increase a soil’s buffering capacity. This procedure provides a way of demonstrating the concept of a buffer.

As a student, you may be surprised to discover that compost with pH near 7 can neutralize an acidic solution. You might think that the compost would need to be basic to counteract the acidity of the solution, or you might expect the pH of the compost to drop corresponding to the increase in solution pH.

The goal of this experiment is to determine whether adding compost to soil increases the soil’s capacity to resist pH change.

What materials are needed?

- Funnel
- Ring stand with attachment to hold funnel
- Filter paper
- 25 mL samples of compost, sand and 1/1 mixture (and any other samples that you want to examine)
- 100 mL graduated cylinder
- vinegar
- pH paper
Experiment, step by step:

Step 1: Attach the funnel to the ring stand

Step 2: Line the funnel with filter paper

Step 3: Place the graduated cylinder below the funnel

Step 4: Measure and record the pH of the vinegar

Step 5: Measure and record the pH of the compost, sand and 1/1 mix sample (and any other samples that you want to examine): moisten a bit of sample, stick a piece of pH-paper in it and read the colour after a few minutes

Step 6: Pour 25 mL sample into the filter

Step 7: Pour vinegar onto the sample until it is flooded (beware that the vinegar does not flow outside of the filter)

Step 8: Measure the pH of the drainage solution at the funnel outlet, at every 5 mL collected drainage solution in the graduated cylinder (keep the sample in the funnel flooded with vinegar). Keep measuring the pH until at least the value 7 is reached or until the sample stops draining

Step 9: Plot the measurements in a graph as below

Step 10: For each sample, calculate the mL of vinegar needed for the drain solution to reach pH=7 and record the results in the table below
Table buffer capacity results

<table>
<thead>
<tr>
<th>sample</th>
<th>pH of sample</th>
<th>mL vinegar needed for drain pH=7</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Table 3: Measuring results ‘buffer capacity’ of compost*

Analysis of the results:
- What happened to the pH of the acid as it filtered through the samples?
- Which sample is best capable of withstanding the effects of acid rain?
- Which sample is least capable of withstanding the effects of acid rain?
- What can you conclude about the buffering capacity of the samples?

Sources:
Nancy M. Trautmann and Marianne E. Krasny, Composting in the classroom, Cornell University, 1997, p. 54, 83-90

http://compost.css.cornell.edu/CIC.html

http://ak.picdn.net/shutterstock/videos/1259008/preview/stock-footage-liberally-pouring-fresh-tomato-seedlings-notably-quickly-the-soil-absorbs-water.jpg

http://www.biocycle.net/wp-content/uploads/2012/05/35_f2.jpg

http://www.rainbird.com/homeowner/images/soil-characteristics-table.jpg

http://nobel.scas.bcit.ca/chem0010/unit1/instrumentLimits/images/volume_gradCylinder.gif

http://img.docstoccdn.com/thumb/orig/108598376.png