THE PERMACULTURE ASSOCIATION

# Permaculture Research: Soil Test Handbook.

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**This booklet should be used with the accompanying *Soil Advice Booklet* and *Soil Record Sheet,* downloadable for free: https://www.permaculture.org.uk/research/soil-yield-and-biodiversity-tests-project**

change your world with permaculture




The Permaculture Research: Soil Test Handbook.
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The Permaculture Association's vision is an abundant world in which we care for the earth, each-other and future generations, whilst living within nature's limits. Our mission is to empower people to design thriving communities across Britain, and contribute to permaculture worldwide.

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# Content

## Introduction

The purpose of the following tests is to measure the quality of your soil from a permaculture perspective. This means that the tests focus on healthy soil that is rich in microbial life and has a good structure. We hope to show that simple, 'farmer friendly' tests like these can provide relevant and accurate results. All of the tests can be done with no special training and no special tools besides everyday items that can be found around your home. The tests will only require a couple of hours of your time. The tests are divided into two separate parts; this test booklet, which shows you how to conduct the tests, and the advice booklet, which helps you understand your soil and explains how you can improve it. There is also a separate soil record sheet to record your results. This set of tests has only been trialled in the UK so far and we expect to discover some parts are not appropriate for different bioregions. We welcome feedback and suggestions for additions that could improve the tests in other regions.

## What these tests won't tell you

Although these tests will tell you a great deal about the health and structure of your soil, particularly about its structure and biological life, there are some things they can't tell you. If you want a full scientific analysis of your soil, we suggest you submit a sample to a reliable testing lab. A lab test will give you a precise breakdown of the nutrients in your soil and its cation potential. Our tests will also not tell you if your soil has been polluted or poisoned; again, a lab test will give you this information.

## A permaculture approach to soil

Throughout the world, modern agricultural practice have had a degrading effect on soil quality. Rather than build up the natural fertility of soil, fertility comes from the addition of mineral and chemical fertilisers. The use of heavy machinery on soil can break down its structure and lead to compaction. In contrast, permaculture seeks to create systems where natural soil fertility is fostered, through the encouragement of worms and other soil fauna and good manual cultivation practices.

In these tests and the accompanying advice booklet, we do not seek to favour forest gardening over raised beds, or no till systems over till systems. There is a wide range of literature that can offer advice on this and each grower will have his or her own opinions. We try to offer general advice that would be applicable in all growing systems.

## Selecting sample locations

When selecting the place to conduct your test, it is important to pick a sample spot that is typical of the site. There are several important factors to consider:

•The slope or gradient relative to the rest of the site

•The drainage of the soil (is it wet and waterlogged or dry?)

•What has the soil been used for (Edible, non-edible etc)

•Ideally the soil has not recently been disturbed (not recently harvested, tilled etc)

•The soil should be bare (you can clear away any grass or vegetation just before you do the test)

## Equipment you will need

•Empty cylindrical baked bean or fruit tin (about 7cm in diameter), with top and bottom removed

•gardening gloves

•500ml bottle

•Water

•Timer (or a watch with a second hand)

•Spade

•Ruler/Tape measure

•Plastic sheet (bin liner)

•Flat bottomed plastic container (at least 7cm x 7cm)

•Fine tip marker pen

•Glass Jar (preferably tall and thin)

•pH paper (*very cheap and easily available from pharmacies, high school chemistry labs, agricultural extension agents, or the internet.*)

•pH chart (included in this booklet)

•flat bladed knife

## Preliminary tests

**Purpose:**
To check you are that your test site is not anaerobic, polluted, waterlogged or too dry.

### 1) Anaerobic conditions and pollution

**The smell test:**
1.Take a handful of soil from the site.
2.Thoroughly smell the handful of soil, does it have a:
•Sour, putrid or chemical smell?
•No smell?
•Earthy, sweet or fresh smell?
3. Record the answer.

### 2) Waterlogging and dryness

**The squeeze test:**

1.Take a handful of soil in your palm and squeeze
2.Observe what happens to the soil:
•*The soil is dry* if there is no water and the soil does not stick together at all when squeezed.
•*The soil is moist* if there is no visible water and no drips, however the soil sticks together slightly and is not dry
•*The soil is wet* if there is visible water which runs or drips out of the soil when squeezed
1.Record the answer.

**If your soil smells sour, chemical or putrid, or if it is so damp that water drips from your hand when you squeeze then this is not a viable area to undertake the soils tests. Choose another site.**

**If your soil is dry some of the tests won't work. Either water this site thoroughly and try again tomorrow or choose another site.**

# Main Soil tests

## 1. Drainage

### Purpose:

To test how well water drains through your soil. Drainage is important if your soil is not going to get waterlogged in wet weather. Clay soil will drain more slowly than sandy soil. Heavily compacted soil will not drain well. Shallow soil will not drain well.

### The infiltration test:

*Equipment: Empty food tin, gardening gloves, 500ml bottle, water, timer*

1.Remove the top and bottom of the tin so you are left with a metal tube
2.Wearing gloves, firmly push the tin into the soil (a piece of wood and a hammer can help with this in firm soil) until it is half-way in
3.Gently use your finger to firm the soil around the edge of the ring, taking care not to disturb the soil in the middle
4.Pour 500ml water as gently as possible into the tin
5.As soon as you start pouring start the timer
6.Stop the timer when the soil surface is glistening rather than submerged
7.Record the time this took. (If the water is still present after 15 minutes record that and move on to the next test)

## 2. Earthworms

*Please note that the earthworm test may not be suitable for all parts of the world. In some places, for example, termites may have a key role in building soil. Please get in touch if you would like to help us develop a test for such places.*

### Purpose:

To establish how many earthworms are in your soil. They are a proxy for all biological life in the soil, large and small.

Please note depending on the time of year and climate there may be variation in the number of earthworms in the top few inches of your soil. In temperate zones, this test is best conducted between April and October as worms retreat deeper into the soil in winter.

### Earthworm count:

*Equipment: Spade, ruler/tape measure, plastic sheet (bin liner).*

1.Dig a 20cm x 20cm pit with a depth of 10cm.
2.Place soil on a flat surface (plastic sheet or bin liner recommended).
3.Count the number of earthworms and record.

## 3. Top soil depth

**Purpose:**

To measure the depth of your top soil. The deeper the top soil, the further roots can grow and the more water and nutrients will be available. Deep soil will also drain better than shallow soil.

**The soil depth test:**

*Equipment: Garden spade, ruler/ tape measure*

**Warning: This will be hard work so please don't overdo it!**

1.Dig a hole at least 60cm deep if possible.
2.If you cannot easily reach this depth make a note in the records section
3.Make a note of the top soil depth. Only measure the top soil; sub soil will be much more compact and probably a different colour. Record which of the following bands it falls into:

- very shallow (<15 cm)
- shallow (15-30 cm)
- moderately deep (30-60 cm)
- deep (>60 cm)

1.Record your results.

## 4. Soil texture

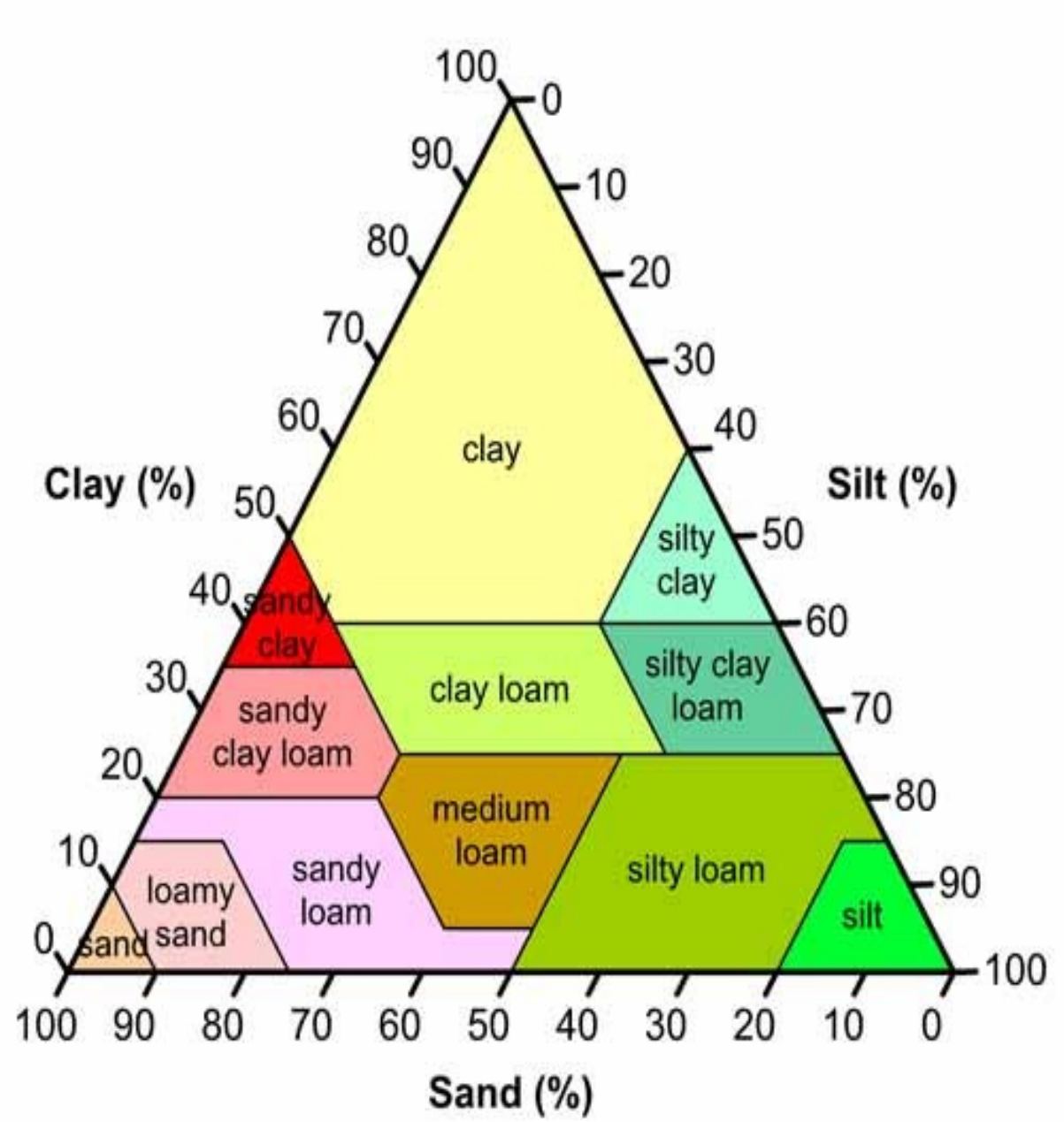
**Purpose:**

To establish the proportion of clay, silt and sand in your soil. Clay soil will hold water and nutrients but is easily compacted and can become waterlogged in wet weather and bake hard in dry weather. Sandy soil holds its structure well but drains quickly and does not hold nutrients well. Silty soils comes in the middle. Loam is a good mix of clay, silt and sand.

**The soil jar test:**

*Equipment: Glass jar, timer, water, ruler/tape measure and a fine-tip marker pen*

1.Remove a vertical slice of soil approximately 30 cm deep from the side of the pit being used for soil tests.
2.Remove any large rocks or organic matter, then break up all the lumps.
3.Fill the jar to the halfway point with soil
4.Using your fingers pack the soil down as much as possible to reduce pore space and mark the level of soil on the side of the jar with a pen.
5.Fill the jar to the ¾ mark with water and shake vigorously for 3 minutes or until the sample is fully suspended in the water.
6.Set the jar on a level surface where it can be left undisturbed for a day.
7.After 1 minute mark on the side of the jar the level of settled particles at the bottom, this is the volume of sand in the sample.
8.After 2 hours mark on the side of the jar the level of settled particles, these particles are the silt in the sample.
9.After the water has cleared (this can take over 24 hours) mark on the side of the jar the level of particles. These particles are the clay in the sample.
10. Using a ruler or a tape measure use the distances on the jar to calculate the relative proportions of sand, silt and clay in the soil samples.
11. Using the soil texture triangle on the next page, determine the type of soil
12. Record your results.




The soil texture triangle

*Image by: Richard Wheeler (Zephyris), Wikimedia*

## 5. Soil structure

**Purpose:**

To find the physical structure of your soil.

**The visual inspection test**

*Equipment: Garden spade, bin bag or plastic sheet*

1.Take a vertical soil slice of approximately 30 cm from the side of the test pit.
2.Carefully lay the slice on its side, preferably on a piece of plastic such as a bin liner to make visibility easier.
3.Now choose which of the following descriptions best fits the sample:
•*Soft:* The soil is crumbly and breaks up easily
•*Cloddy:* The soil breaks into lumps (clods) that are difficult to break down
•*Platey:* The soil breaks into flat plates that are difficult to break down.
1.Record the result.
2.Inspect the soil for any bands of discolouration or hard, compact soil running horizontally. This may indicate a layer of compaction known as a *pan* that will prevent water, nutrients and plant roots penetrating deeply into your soil.
3.Record the result.

**The slaking and dispersal test:**

*Equipment: Flat bottomed plastic container, water, teaspoon*

1.From the visual inspection sample select three pea-sized lumps of soil.
2.Fill the container with rainwater and place it on a flat, stable surface.
3.Use the teaspoon to place the lumps in the water, equally spread apart.
4.After 2 hours record the degree to which slaking (when the small lumps have broken down into smaller particles as a result of being immersed in water) has taken place:
•Completely (indicated when the base of the container is covered with a layer of clay and there is only a pile of sand where the aggregates were)
•Partially (indicated when a milky 'halo' has developed round lumps)
•Not at all
5.After 24 hours record whether dispersal is complete or partial.
6.Record your results.

## 6. Soil pH

*pH testing paper (litmus paper) is very cheap and is easily available from pharmacies, high school chemistry labs, agricultural extension agents, or the internet.*

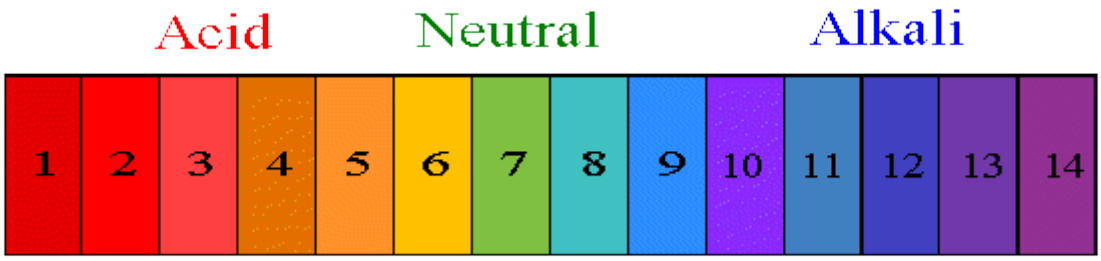
**Purpose:**

To establish the acidity or alkalinity of your soil. PH can range from 1 (very acid) though 7 (neutral) to 14 (very alkali). Most plants need a pH between 6 and 7.5 to grow well, although a small number are suited to a pH outside this range.

**The pH test:**

*Equipment: pH paper and chart, cup, water (distilled or rain water if possible).*

1.Fill a cup 2/3 full with soil.
2.Add just enough water to cover the soil sample.
3.Stir the contents for approximately one minute.
4.Completely immerse the pH strip in the soil solution for 3 seconds
5.Remove the strip and quickly rinse with water (the water must be from the same source as was used in the solution)
6.Hold the pH paper up to the light and compare the colour to the attached colour table to identify the pH of the soil.
7.Record your result.



## 7. Soil Compaction

*Although one of the most useful tests, this is also the most complex so you may wish to skip it if you are short of time.*

**Purpose:**
To see how compacted your soil is. Roots and shoots will find it hard to grow through compacted soil. They much prefer loose, crumbly soil.

**The bulk density test:**
Equipment: Garden trowel, flat bladed knife, sealable bags, marker pen, scales, tin, ruler

1.Remove the top and bottom of the tin so you are left with a metal tube
2.Measure the diameter of the tin, then half it to give the radius
3.Firmly push the tin into the soil (a piece of wood and hammer can help with this in firm soil) until it is at least 2/3 of the way in
4.The exact depth that the tin has gone into the soil must be determined, so using the ruler measure the height from the top of the tin to the soil surface four times evenly spaced and record the average, subtract this from the total height of the tin to get the depth the tin has gone into the soil
5.Using the trowel carefully dig around the tin to remove it, it is very important not to disturb the soil in the bottom of the tube
6.Remove excess soil from the bottom of the tube with the flat bladed knife, the soil surface should be flat and level with the end of the tin
7.Place the entire soil sample in a plastic bag and label to take home
8.The soil must be completely dry before bulk density can be calculated so depending on the climate either allow soil to dry in a warm place over night with the bag open or place in an oven on a low heat.
9.Weigh the dried soil and record the weight
10. Calculate the bulk density of your sample using the following equation:

$$\text{Bulk density} = \frac{\text{Mass of soil (g)}}{\text{Volume of soil (cm}^3\text{)}}$$

Mass of soil = Dry weight of soil

Volume of soil = Depth of soil in tin (step 4) x radius of tin (step 2) x radius of tin x 3.14

Record the bulk density.