DO-IT-YOURSELF SOIL TESTS

Version: July 2023

Authors: Matthias Stahlhofer, Hans Unterfrauner

Let's get dirty!

By conducting simple soil testing methods, **sum parameters** can be determined for a quick **assessment** of a site. It can thus already be determined in the **field** whether **certain problems** (e.g., poor aggregate stability, acidification) **exist**, while the underlying **cause cannot** be determined.

Ideally, these soil tests should be carried out at the same time for several, preferably different soil types/locations, so that the **relative differences** can be better displayed. Documentation with a camera, mobile phone or table is recommended for later checking whether, for example, a change has occurred at the specific site. A special focus should be placed on the examination of the **"neuralgic" soil layer** (**top 0 - 5 cm**), as this area is decisive for the assessment of soil fertility.

Determination of aggregate stability (left) and pH value in neutral salt (right)

The materials required are simple, inexpensive, and usually easily available. The following **soil tests** will be presented:

Tab.: Overview of described do-it-yourself soil tests

Soil test	Required materials
1) Assessment of aggregate stability by means of turbidity test	Slim vessel (cut-off PET bottle, glass, cylinder, eprouvette), distilled water
2) Measurement of pH value in water	Vessel, distilled water, indicator strips/ electronic pH meter
3) Measurement of pH value in neutral salt	Hellige pH meter with indicator liquid (e.g. from *Pronova*)
4) Carbonate test (lime content)	Hydrochloric acid (10%)
5) Soil texture by finger test	Water
6) Measurement of infiltration	PVC pipe, water, (ev. floating device)

Assessment of aggregate stability by means of turbidity testing

Stable aggregates are an essential prerequisite to ensure the optimal water and air balance of the soil, create favourable **environmental conditions** for microorganisms and promote the **drainage** of surface water (e.g., during heavy rainfall) into the soil body through improved infiltration.

A favourable aggregate stability not only increases the water storage capacity of the soil, but also effectively reduces soil erosion. A variety of physical, chemical, and biological factors influence the aggregate stability of a soil, such as:

- Soil life (root, earthworms)
- Calcium and magnesium bridges
- Soil cover (e.g. vegetation, mulch)
- Soil texture (sand, silt & clay content)
- Organic matter content
- Mineralogy (e.g. content of iron oxides)
- Tillage

Required materials:

- Slim and tall jar / vessel (glass, cylinder, eprouvette, cut-off PET bottle)
- Distilled water

Stable crumble structure

Procedure:

1) Carefully crumble the soil material and fill it into a vessel (approx. 1/3); get rid of roots and gravel (grains >2mm)

2) Fill up with distilled water up to approx. 1 cm below the edge of the vessel

3) Cover with your hand and tip overhead for 1 to 3 minutes until the soil is completely mixed with the water (do not shake)

4) Put the vessel into a stable (standing) position and let it rest for at least half an hour, then assess the turbidity of the supernatant liquid


Soil mixed with water

NOTE: The soil shaken with distilled water can be used directly to measure the pH in the water (see soil *test number 2*).

Assessment:

The **supernatant liquid** is being assessed.

➡ Is it **clear or clouded**?

- **Clear liquid = stable aggregates**; great stability of the crumbs due to intact soil biology, water-stable clay-humus complexes, stable Ca and Mg bridges, good soil structure. **Low risk** of erosion and crusting; proper water and air infiltration, active soil life.

- **Turbid liquid = moderately stable aggregates**; possibly due to reduced biological activity, disbalance between Ca and K. **Medium risk** of erosion and siltation / soil crusting; restricted air and water infiltration.

- **Turbid liquid = unstable aggregates**; decreased biological activity, Ca deficiency, imbalance of Ca, Mg and K. **High risk** of erosion and siltation / soil crusting, lack of air infiltration into the soil.
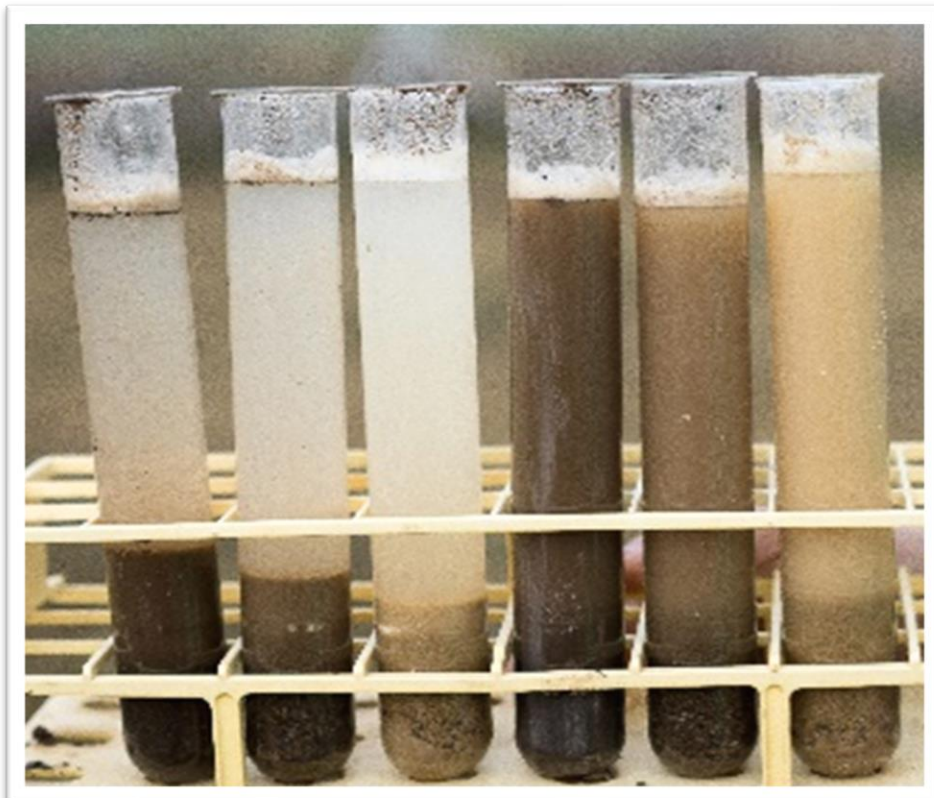
Comparison of the turbidity of the supernatant liquid of different soil samples to assess the aggregate stability

Measurement of the pH value in water

The pH value in distilled water corresponds to the concentration of hydrogen ions (H^+ ions) in an **aqueous solution** and is therefore a useful parameter to assess the **acidity** of a **"water-filled soil pore"**. This sum parameter is important to characterize the environmental conditions for **soil life** and is furthermore an important indicator of **nutrient availability**.

Required materials:

- Slim, tall jar / vessel (glass, cylinder, eprouvette, PET bottle)
- Distilled water
- Indicator strips (e.g., from *Merck, Macherey-Nagel*)

Procedure:

➡️ **Either take the prepared sample from *soil test 1* or:**

1) Carefully crumble the soil material and fill it into a vessel (approx. 1/3); get rid of roots and gravel (grains >2mm)

2) Fill up with distilled water up to approx. 1 cm below the edge of the vessel

3) Cover with your hand and tip overhead for 1 to 3 minutes until the soil is completely mixed

4) Hold and steer pH indicator strip in supernatant liquid for approx. 10 seconds

5) Comparison of colours to estimate the pH value (at least two colour "boxes" should match)

pH indicator strips in action

Assessment:

The pH value corresponds to the negative decadal logarithm of the H^+ ions in the solution, this means that a pH 6 is 10 times and pH 5 is a hundred times more acidic than pH 7. The ecological evaluation of the results can be found in the following table. The aim is to achieve a **pH value in water between 6.5 - 7.5.**

Tab.: pH value ranges in the water and ecological evaluation

pH value in water	Description	Evaluation
> 7.5	alkaline	Biological activity restricted
7,5 - 6,5	**neutral**	**Optimal (highest activity + diversity)**
6,9 - 5,9	weakly acidic	Biological activity restricted
5,5 - 4,5	strongly acidic	Biological activity severely restricted
< 4.5	very strongly acidic	Biological activity is scarce

Measurement of the pH value in neutral salt

The pH value in neutral salt corresponds to the concentration of hydrogen ions (H^+ ions) in an **exchanger solution** and is therefore a useful value for the **characterization** of the **readily interchangeable acids** of a soil. By measuring the pH value in neutral salt (usually KCl or $CaCl_2$), a statement can be made in which acid **buffer system** the soil is currently located.

Required materials:

- pH meter with indicator liquid (e.g. type *Hellige PEHAMETER*)
- Measuring spoon
- Distilled water for subsequent cleaning

Procedure:

1) Fill the soil with the measuring spoon (approx. half full) into the designated pit of the pH meter. Do not use your fingers (sweat = acid!)

2) Add the indicator solution (you need more solution than soil material)

3) Carefully tilt back and forth for approx. 1 minute (let it flow over the gutter) and let it react: the soil pores should be "permeated" by indicator liquid so that the exchange processes can take place

5) Colour matching for estimating the pH value possible up to max. 10 minutes (liquid should not be dried). Then clean thoroughly

pH measurements (neutral salt) at different depth levels

Assessment:

In general, the **pH value in neutral salt** is **usually lower**, but can be at most the same value as the pH value determined in distilled water, since the neutral salt (KCl, $CaCl_2$) mobilizes exchangeable acids. Ideally, the difference between the two pH values should be about 0.5 to 1 pH units (if both values are in their optimum range). The aim is to achieve a **pH value in neutral salt** between **5.9 - 6.9.**

The **assessment** of the results can be found in the following table:

Tab.: pH value ranges in neutral salt, including description and evaluation

pH value in neutral salt	Description	Evaluation
< 7.5	alkaline	Determination of substances
7,5 - 6,5	neutral	Subsequent delivery restricted
6,9 - 5,9	**weakly acidic**	**optimal**
5,9 - 4,5	strongly acidic	Decay of clay minerals
< 4.5	very strongly acidic	Collapse of soil structure

Measuring the pH value in neutral salt solution helps to classify the soil into its currently active **buffer system**. Soils do not acidify linearly, but instead the different buffer systems become gradually exhausted, acidification takes place in stages. **Attention:** the measurement can only be used to determine **WHICH** active buffer system the soil can currently be assigned to, but not **WHERE** in the specific buffer system. Thus, **no precise liming recommendations** (e.g., quantity, chemical formulation) can be derived from this measurement!
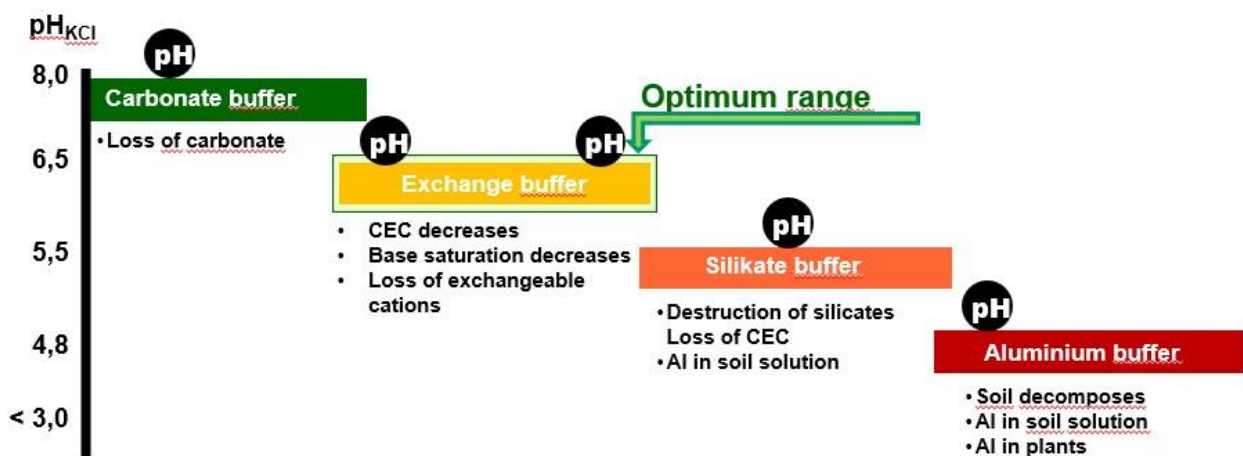

Fig.: Different buffer systems of soils (© TB Unterfrauner GmbH)

- **Carbonate buffer** (verify with *carbonate test*): **pH > 7**
  mostly in calcareous soils; carbonate compounds in the soil (e.g., $CaCO_3$ or $MgCO_3$) quickly neutralize acids. The **dynamic processes**, such as the mobilization und subsequent provision of nutrients, may be **restricted**.
- **Exchanger buffer: pH 5.9 - 6.9**
  favourable for most soil functions (**optimum**). Acid is buffered by exchange processes, nutrients are mobilized and there is a vivid dynamic in the soil.
- **Silicate buffer**: **pH < 5.9**
  Aluminium from the Al-silicates begins to dissolve, clay minerals and, subsequently, the soil structure decay. **Acute need for action!**

4

Carbonate test

By conducting the carbonate test, it is possible to determine whether **carbonate compounds** (e.g., calcium carbonate or dolomite) are present in the soil. Carbonates **neutralize acids** and thus "buffer" the soil against acidification.

NOTE: This test is very useful when taking soil samples, to make sure to combine only individual samples with similar properties (e.g., carbonate-containing/non-carbonate-containing) into a composite sample.

Required materials:

–   10% hydrochloric acid (HCl)

Procedure:

1)   Carefully sprinkle the soil with the hydrochloric acid and check the reaction

10% hydrochloric acid (left) and foaming reaction in the presence of carbonates (right)

Assessment:

If a soil contains calcium/magnesium carbonates, they react with hydrochloric acid and produce the gas CO_2 (reaction: foaming/sparkling or "crackling"). The chemical reaction proceeds as follows (for calcium carbonate):

$$CaCO_3 + 2\,H^+ = Ca^{2+} + CO_2 + H_2O$$

A pronounced **foaming** indicates that **carbonate compounds are present**, the soil can be assigned to the "carbonate buffer". Carbonates are neutralizing acids and thus hinder soil acidification.

NOTE: *Listen carefully*! If there is no clear foaming or sparkling, but an audible **"crackle"** can be noticed, carbonates (about 0.5 - 2%) are still present.

Evaluation of the observed reactions:

Tab.: Observed reaction, estimated carbonate content and evaluation

Reaction HCl	Carbonate content (approx.)	Evaluation
no reaction	< 0.5%	lime-free
crackle	0.5 - 2%	weakly calcareous
clear foaming / sparkling	2 - 5%	moderately calcareous
strong foaming	> 5%	Highly calcareous

- **Foaming, sparkling** or distinct **crackling**

Soil is usually protected from acidification and does not need additional liming measures to maintain its buffer capacity. However, it is not possible to estimate whether Ca or Mg fertilization would be necessary for plant nutrition or to improve the aggregate stability of the soil.

- **No reaction:** the soil is **free of carbonates**

Liming to neutralize acids may be required. In this case, the pH value(s) should also be measured, and the liming requirement should be determined via laboratory soil analysis

NOTE: If a **reaction** (e.g., foaming) is observed, you can theoretically **skip the pH measurements** (water + neutral salt), as the soil is most likely located in the range of the **carbonate buffer** (pH neutral - alkaline)!

This test is very useful to estimate a possible gradient of acidification in the soil pit. If a reaction occurs at greater depths, this is an indication that it was originally a calcareous soil and/or formed on parent material rich in carbonates (e.g. loess).


© TB Unterfrauner (2022) – We take a different look at your soil!

Soil ribbon test: Determination of soil texture

The finger testing (soil ribbon test) can be used to estimate the texture of the fine soil (< 2 mm). The **texture** of a soil corresponds to the **composition (%)** of the different **particle sizes** of a soil, with the following (Austrian) classification:

- **Sand** (S) = 63 μm to 2 mm
- **Silt** (U) = 2-63 μm
- **Clay** (T)= < 2 μm
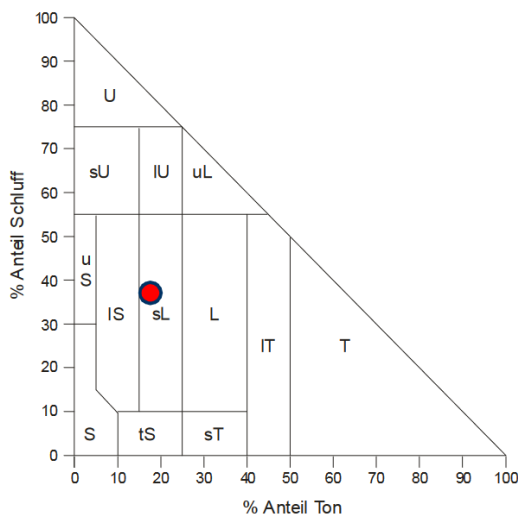
Austrian texture triangle according to **ÖNORM L 1050** (left) and soil material rolled into ribbons (right)

Soil heaviness refers to the (mechanical) **workability** of the soil. *Light* soils are sandy to silty soils, *medium* soils are loamy soils and *heavy* soils are clayey soils.

TIP: The soil type **loam** consists of approx. **1/3 sand, loam and clay** and turns out to be a favourable type of soil for most crops due to the uniform distribution of coarse, medium and fine pores.

Such an assessment is ideal, for example, for the description of a soil pit, since differences in soil texture are often evident in depth (e.g., clay translocation).

Required materials:

- Soil material (field moist)
- Water for moistening

Procedure and assessment:

1) **Remove coarse components** (> 2mm) such as stones and roots from the sample

2) **Moisten** the sample, **if necessary**, with water

3) In a first step, try to form **"Dumplings"** in your hand. If this does not work and the soil crumbles without structure, you are dealing with a very sandy soil texture.

4) When rolling and shaping the scoop, pay close attention to what you **feel between the fingers**. **Visually resemble** the **Palms** (and finger grooves):

   – Is the soil granular, can you feel single grains? **SAND**
   – Does the soil feel "floury" or velvety? **SILT**
   – Does the soil stick to the fingers and do the palm surfaces shine? **CLAY**

5) Once a "dumpling" has been formed, it is now time to determine more precisely whether silty or clayey components dominate the sample.
   To do this, try to form a roll (**"sausage"** or ribbon) between the **palms of your hands** (up to about the thickness of a pencil) and pay attention at which length the **ribbon** crumbles/breaks:

   – Can the sample be rolled out, but will it crumble if you roll it out a second time? **SILT**
   – Can the sample be rolled out repeatably down to a ribbon half the thickness of a pencil without any problems? **LOAM/CLAY**
   – Is the specimen plastically easily deformable and greasy? **CLAY**
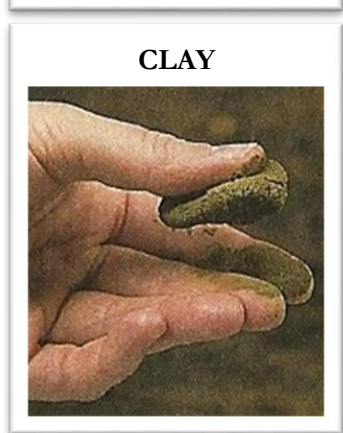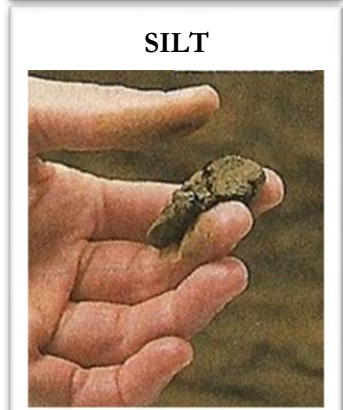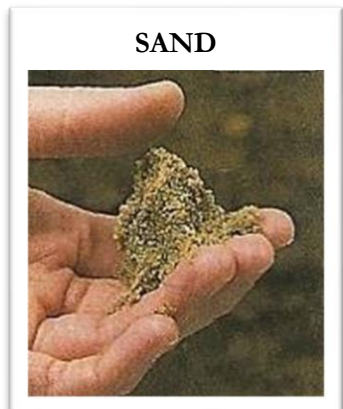
NOTE: A high proportion of organic matter (e.g., in horticultural topsoils) "sticks" the individual soil particles together in a similar way to clay and can lead to a slight overestimation of the clay content. For agricultural practice, a division into **light, medium** and **heavy** soils is usually sufficient.

SAND

SILT

CLAY

Ribbon test

By measuring the infiltration velocity, conclusions can be drawn about the **water conductivity** of soils. *Infiltration* is defined as the penetration of precipitation into the soil and is most often measured in **mm per hour** or **minute**. For the measurement, usually a **pipe** is used, which is rammed into the ground and **filled with** water **up to a defined height**.

Proper infiltration into the soil is, among others, essential for **flood protection** and determined by several **factors**:

- Pore sizes and pore distribution (e.g., earthworm tubes, cavities, dead roots)
- Stability of the soil aggregates
- Water saturation (pre-moisture)
- Soil cover (vegetation)
- Precipitation intensity

Required materials:

- Cut-off PVC pipe or (double) ring infiltrometer (for scientific use)
- Optional: floating device
- Sufficient water (see *table below*)
- Timepiece (watch, mobile phone)

Measurement of infiltration with PVC pipe (above) or double ring infiltrometer (below)

Procedure:

1) First, the pipe or ring is **rammed into the ground** (under the turf in the case of grassland) so that the used gear (tube, infiltrometer) stands upright and filled water cannot leak out immediately on the side.

2) When using a **floating device**, it is now installed*),* whereby care is taken to ensure that it is not "disturbed" in its vertical movement by vegetation etc. within the diameter examined.

3) Next, water is **poured in,** and the **time measurement** starts immediately: the **volume or initial level** of the **water column/floating device** is noted**.**

4) After defined **time intervals** (e.g., every 2 minutes), the level **of the water column / floating device** is noted. You can also skip these intermediate measurements and wait until the water has completely seeped away and note the **end time**.

Tab.: Selected diameters of pipes, filling levels and water quantities

Ø (cm)	Filling height (cm)	Filled in Volume (l)	≙ (mm) ≙ (l/m²)
10	20	1,6	200
16	20	4,0	200
16	30	6,0	300
20	20	6,3	200
25	20	9,8	200
25	30	14,7	300

PVC pipe with marked depth and indicated filling height (10cm)

Assessment:

Since the filling height and diameter of the **water volume are known** (see examples in the table above), the **infiltration can be determined over time**. If, for example, in the case of a PVC pipe with a diameter of 16 cm and a filling height of 20 cm, all the water (4.0 l) seeps away in one hour, this corresponds to a quantity of around 200 l/m² (200 mm).

1 mm of infiltrated water column corresponds to 1 litre/m² or 10 m³/ha – regardless of the diameter of the pipe or ring! The **objective** would be for arable soils to be **able to absorb > 100 litres/m² per** hour, which corresponds to a change in the water column of **> 10 cm/hour**.

NOTE: This soil test measures the **unsaturated hydraulic conductivity**. In most cases, the initial infiltration is particularly high in soils with low pre-moisture and decreases with the degree of saturation towards saturated conductivity.