Instructions for the

KNIFFELIX.DE Topic
Earth / Soil / Water Absorption

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&

Experiment
„Soil types and their water absorption: Which soil does my plant need?“

(Experiment can also be done without KNIFFELIX.DE)

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Teacher Instructions:
Soil types and their water absorption:
What soil does my plant need?

Aims of the lesson:

- Encourage people to perceive, question and explore everyday phenomena
- Learn to carry out experiment instructions independently in small groups
- Learn about the components of soil
- Understand the nature of the three soil-types sand, clay and loam as well as selected factors relating to the water absorption capacity of soils.

1. **Introduction** (Have pictures of different plant types ready to show.)

Plants have very different water requirements. Therefore, the plants that can be found in particularly dry or wet regions of the earth are different. Here we see pictures of different plant species. Do these plants need a lot or a little water?

Project or hold up pictures of different plants from different regions.

Examples of plants found in dry regions:

- Cactuses (desert),
- Agaves and aloes (steppe)
- Coniferous trees (Tundra)

Examples of wetland plants near marshes and flooded plains:

- Mosses
- Ferns
- Reed
- Bulrush
- Wild rice

Examples of wetland plants in rainforests:

- Orchids
- Rhododendron
- Lianas and climbing plants

Example of aquatic plants:

- Water lilies
- Seaweed

Do you know these plants? Where on earth do they grow?

Plants grow in the most diverse places on our planet: in dry regions such as the desert and in wet regions such as the rainforest.

Imagine you were traveling to the rainforest and dug up a plant that you later wanted to put in a flowerpot at home. What would you need to be able to plant the plant in a flowerpot?

Soil with which the flowerpot can be filled

Kniffelix Mission 1

Exactly, soil! But that's easier said than done. If you've ever been to a gardening store, you'll know that you can buy all kinds of different soils there. So, not all soils seem to be the same. But, what kind of soil would our plant need? That's what we want to find out today by experimenting. First, let's take a look at what soil actually consists of.

Mostly our soil consists of grinded rocks. Rock can take the form of large or small stones, gravel, sand, or all the way down to fine grains of clay. Depending on the composition of the rock grains in the soil, we speak of different types of soil. We will now take a closer look at the properties of the different types of soil in our experiment.

2. **Experiment 1: „Finger sample for soil type determination “**

Material needed per group (4 pupils per group) or as a demonstration experiment:

- 4 Worksheets: „Finger samples for soil type determination“
- One tablespoon of each of the soil samples provided: sand, loamy soil, clayey soil or plant soil (To save material, the different groups can each take a different sample, and the groups can chen compare their samples with each other.)
- Some water to moisten the soil samples
- Optional: A shovel, if you want to collect soil from outside yourself.

The experiment can be carried out outside. When carrying out the experiment indoors, spread newspaper on tables so that these can be tidied up quickly when finished.

3. Discussing Experiment 1 “Finger sample for soil type determination“

What observations have you made?

Sandy soil:

- Sand grains are up to two millimeters in size.
- Soil with a high sand content feels rough and grainy.
- Sand is not moldable.
- Sand trickles through spread fingers.

Clayey soil:

- Clay grains are so fine that they cannot be seen with the naked eye.
- Clay grains have a maximum size of 0.002 millimeters.
- Soil with a high clay content is smooth and shiny.
- Clay is easy to shape, it can be rolled out well.
- Clay dyes fingers the color of the clay.

Loamy soil:

- Loam is a mixture of clay, sand and so-called silt
- Silt grains are soil particles with a size of 0.002 to 0.063 millimeters.
- Loamy soil feels grainy to floury
- Loamy soil is not very moldable. It can be rolled out to pencil thickness and then crumbles.
- Loamy soil sticks in finger grooves.

Conclusion:
Due to their different compositions, different soils have different properties.

So, what about water absorption? How well can the different types of soil store water? Many factors play a role here, such as the particle size, the composition, the surface properties of the particles and the absorbency of the particles. We cannot investigate all these factors at the same time. Today we are comparing four given soil samples: sand, clayey soil, loamy soil and plant soil. The plant soil is water-repellent if it is extremely dry. It may need to be somewhat moistened.

(Additional ideas: The different groups can compare very dry plant soil with slightly moist plant soil and consider what problem occurs when there is suddenly heavy rain after a drought. Furthermore, if you have dry sponges the groups can discover that completely dry sponges absorb less at first than moist sponges.)

4. Experiment 2: „How much water can soils absorb? “

Spread newspaper on the tables beforehand, so that things can be tidied up quickly later.

Either go through the experiment setup sheet and the double-sided worksheet with the students before the experiment and discuss what they should observe or tell them before the experiment:

- They should read the instructions carefully and follow them precisely.
- They should read through BOTH sides of the worksheet before the experiment, so that they know what to look out for during the experiment.
- Carefully make nine holes in the bottom of each cup (as shown in the instructions) without destroying the bottom of the cup as a whole!
- If one drop of water is not enough to moisten the paper towel at the bottom of the cup, you can moisten it with another 1-2 drops.
- The aim of the experiment is to observe the different water storage capacities of the soils.
- The exact times after which the water starts to drip are not necessary. It is better to add the water to the samples at the same time and make comparative observations. For this it is good to determine two group member who add the water and two which observe which samples drip first. Communication within the group is important!

Kniffelix Mission 2

Material per group (4 pupils per group):

1x Instructions “How much water can soils absorb?”
4x Worksheet “How much water can soils absorb?“

Per soil sample:
1 paper cup
1 tablespoon
50 ml measuring cup
1 clear glass / clear cup *

You will also need:
2 toothpicks or wooden skewer to perforate cups
1 piece of paper towel
1 pen for labeling the paper cup
1 pair of scissors
1 measuring cup for approx. 250 ml water
250 ml of water per group (or a little more)

* The paper cup will later be suspended in the glass/cup. There should be enough space between the bottom of the cup and the bottom of the glass to catch the water running through. See pictures in instructions!

5. Discussing Experiment 2 “How much water can soils absorb??“

What observations have you made?

Kniffelix Mission 3

Sand: Most of the water has flowed through the sand. A lot of air can accumulate between the coarse, grainy sand particles. The many air cavities allow the water run through the sand quickly. The water adheres poorly to the sand particles. This means, that a plant has little water at its disposal because the sand does not store it. The sand cavities ensure that a soil containing much sand is well aerated and warms up quickly. This also means that sandy soil can dry out quickly.

Clayey soil: The fine grains of clay lie so close together that water has difficulty passing through. It forms puddles on top of the clay easily. The closely packed grains form a large surface area. The water has a lot of contact with the clay grains. It therefore adheres to them very well. However, the clay grains hold on to the water so strongly, that the roots of the plants have difficulty pulling the water out of soil containing much clay. This is why the term “dead water” in the clayey plant soil is used, because it contains water but does not release it to the roots of plants easily, and therefore doesn´t work. The water is said to be dead.

Loamy soil: Due to the mixture of different grain sizes, loam can hold more water than sand but is not as impermeable as clay. Loamy soils are therefore good water reservoirs. Plants have enough water available here and the water is released to plant roots easily.

Plant soil: Dead plant remains, such as withered leaves or peat, can increase the water storage capacity of a soil. This so-called humus layer can surround itself with a layer of water and thus store a lot of water. In this way, the soil soaks up water and can gradually release it back to the plants. Plant soil has a very different water absorption capacity depending on its composition and current moisture content. The composition of the plant soil can be changed by adding clay, loam, humus or other additives. But, completely dry soil is like a dry sponge: both absorb little or no water at first. A slightly damp sponge, like slightly damp soil, absorbs water much better!

Now that you have learned about the different types of soil and their ability to absorb water, what soil composition would you say our plant from the rainforest needs when planted in a flowerpot?

Plants from the rainforest are wetland plants that are used to having plenty of water available. Accordingly, they will prefer a soil that can store a lot of water. This means that the soil should have different grain sizes and a high humus content.

Material needed for the Experiments: Soil types and their water absorption for 24 pupils

1x	Teacher Instructions
24x	Worksheet: “Finger sample for soil type determination”
24x	Worksheet “How much water can soils absorb?”
24x	Knowledge-Box: “Water absorption of soils”
1x	Projected or printed plant pictures for the introduction of the lesson

For each of the six groups: (4 pupils / group)

2x	Instructions “How much water can soils absorb? “
(1x	Shovel (optional: if the participants are to get their own samples from outside))
(1x	Plastic bag or container for soil sample from outside, if desired)
1x	Container for water (volume approx. 300 ml)
250 ml	Water (plus a little extra)
4x	Measuring cups for measuring and storing 50 ml each
2x	Toothpicks or wooden skewers to perforate cups (see picture on instruction sheet)
1x	Sheet of paper towel
1x	Scissors
1x	Pen for labeling the paper cups and marking the kitchen towel (non-water soluble)
4x	Paper cup (1x for each soil sample in a group)
4x	Clear glass/beaker for under paper cup (1x for each soil sample in a group) (see picture on instruction sheet)
4x	Tablespoon (1x for each soil sample in a group)

Provide centrally:

- Newspaper to cover the tables
- At least 1.5 liters (36 tablespoons) each of different soil samples:
  sand, loam or loamy soil, clay or clayey soil and slightly moist plant soil
- 4 tablespoons (one for each type of soil) If you have more soil types, more tablespoons if necessary.
- Optionally, if you want to expand the topic, other types of soil, e.g. from a gardening store: Mediterranean plant soil, balcony and potted plant soil, cactus and succulent soil, ...
- Note: If you are testing more than four soil samples, each group will need an additional paper cup, a clear glass/beaker and a tablespoon for each soil type, etc.!

Cactus

Dry plants in deserts

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Picture 1

Coniferous trees

Dry plants on high mountains

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Picture 2

Orchids

Rainforest plants in Costa Rica

Wetland plants: Lianas, climbing plants, ferns

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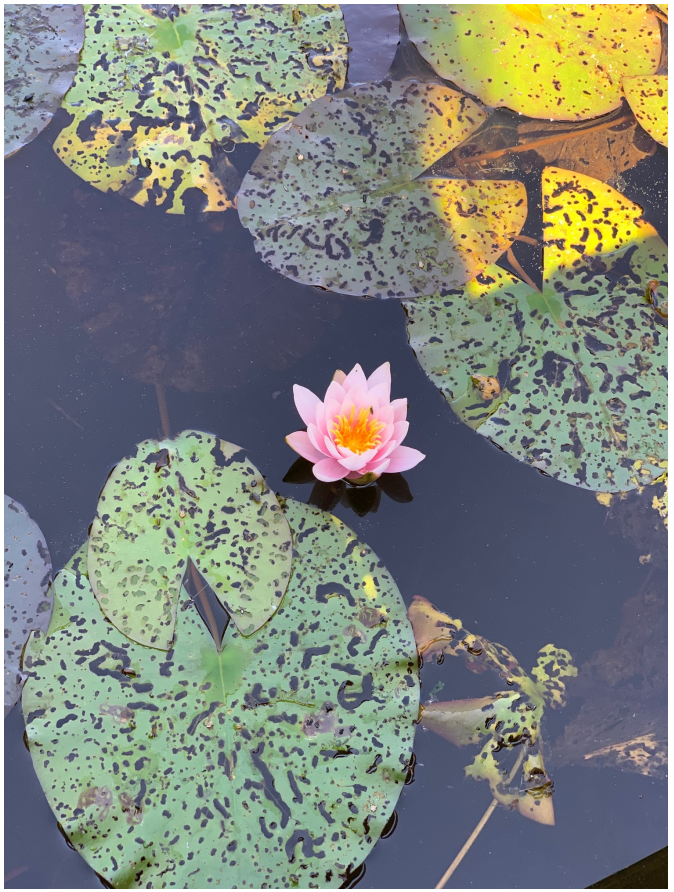
Picture 4

Water lilies



Aquatic plants on ponds and lakes

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Picture 5

Seaweed

Aquatic plants in the sea

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Picture 6

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Experiment 1
Finger sample for soil type determination

Sandy, clayey or rather loamy? What kind of soil do you have in front of your doorstep? Get a shovel full of soil and try to find out with the finger sample test! If you want you can try this with different soils from different places!

First remove larger stones and plant roots. If the soil is very dry, drizzle some water over it. The soil should be so moist that it sticks to your fingers. Compare your soil sample to the following basic components of soil:

Sand

Loam

Clay

Grind the soil sample between your thumb and forefinger. How does the soil feel? Mark which answer applies.

- ☐ Rough and grainy → sandy soil
- ☐ mealy and velvety → loamy soil
- ☐ smooth and sticky → clayey soil

Try to roll the soil sample between your hands into a sausage about the thickness of a pencil. What do you notice?

- ☐ The soil cannot be rolled at all. → sandy soil
- ☐ The soil can be shaped a little.
  I can roll the soil into a sausage the thickness of a pencil,
  but it quickly crumbles again. → loamy soil
- ☐ The soil is easy to shape.
  I can roll it out into a thin sausage. → clayey soil

My soil is a _____.*

* If you cannot clearly determine your soil, then particles of different sizes are probably mixed in your soil. For example, there is clayey loam, i.e. loam with a high clay content.

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Experiment 2
Instructions: How much water can soil absorb?

Materials:

Get various soil samples such as plant soil, sand, clay or clayey soil and loam or loamy soil (6 tablespoons of each sample).

For each soil sample you need:

- 1 paper cup
- 1 tablespoon
- 50ml measuring cup for water
- 1 clear glass / clear cup *

You will also need:

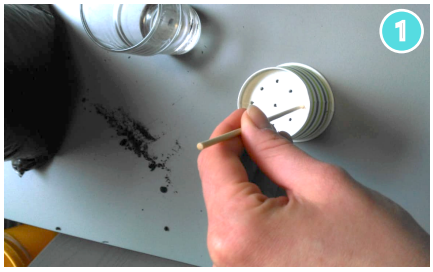
- 2 toothpicks or wooden skewer to perforate cups
- 1 piece of paper towel
- 1 pen for labeling paper cup
- 1 pair of scissors
- 1 measuring cup with 250 ml water
- 1 worksheet “How much water can soil absorb?”

* The glass should be chosen so that you can hang the paper cup in it like shown in the picture on the left. There should be enough space between the bottom of the cup and the bottom of the glass to catch the water running through.

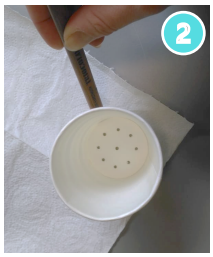
Experiment setup and execution:

(Before you start, read this page and both pages of the worsheet!)

1. Carefully poke nine holes into the bottoms of the paper cups with the wooden skewer as follows: make a circle of eight holes and a hole in the middle.

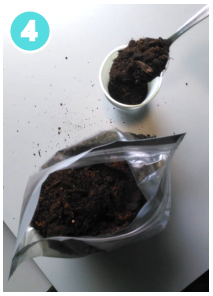


2. Place the paper cups on the paper towel and trace the edge of the bottom of the cup.



3. Cut out the marked circles, place them in the paper cups and moisten them with 1-3 drops of water. Make sure that the paper towel sticks tightly to the bottom of the paper cup and that all the holes are covered.

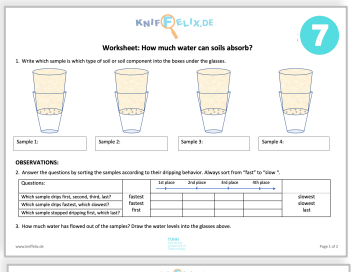
4. Place the paper cups into the glasses. Fill each paper cup with 6 tablespoons of a soil sample. Make sure that you distribute the soil evenly in the cups.

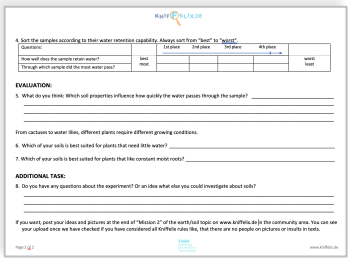


5. Label your samples (e.g. loam or loamy soil, sand, ...).

6. Pour 50 ml of water into each of the paper cups at the same time and compare *:
   - How quickly does the water start to drip from the samples?
   - How quickly does drop follow drop?
   - How quickly does it stop dripping from the samples?

7. Note your observations on the worksheet.





* Before adding water, see what you should note on the double-sided worksheet and how? NO times need to be measured! Observe the results in comparison to each other! Decide which group members will pour the water and wo will watch in which glass the water drips fist and last.

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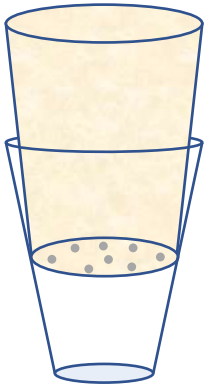
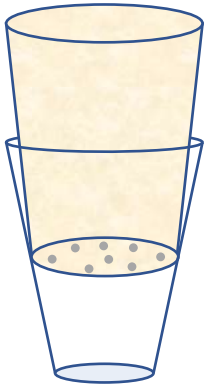
Worksheet: How much water can soils absorb?

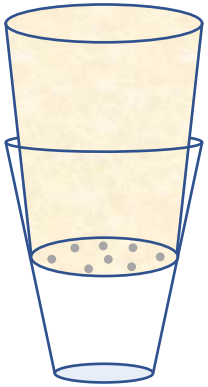
1. Write which sample is which type of soil or soil component into the boxes under the glasses.



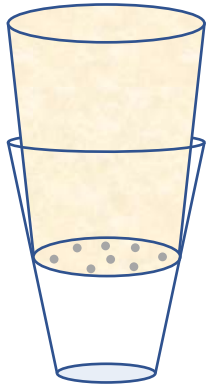
Sample 1:



Sample 2:



Sample 3:



Sample 4:

OBSERVATIONS:

2. Answer the questions by sorting the samples according to their dripping behavior. Always sort from “fast” to “slow “.

Questions:		1st place	2nd place	3rd place	4th place	
Which sample drips first, second, third, last?	fastest fastest first					slowest slowest last
Which sample drips fastest, which slowest?						
Which sample stopped dripping first, which last?						

3. How much water has flowed out of the samples? Draw the water levels into the glasses above.

4. Sort the samples according to their water retention capability. Always sort from “best” to “worst“.

Questions:		1st place	2nd place	3rd place	4th place	
How well does the sample retain water?	best					worst
Through which sample did the most water pass?	most					least

EVALUATION:

5. What do you think: Which soil properties influence how quickly the water passes through the sample? _____

_____

_____

_____

From cactuses to water lilies, different plants require different growing conditions.

6. Which of your soils is best suited for plants that need little water?_____

7. Which of your soils is best suited for plants that like constant moist roots? _____

ADDITIONAL IDEAS:

8. Do you have any questions about the experiment? Or an idea what else you could investigate about soils?

_____

_____

_____

If you want, post your ideas and experiment pictures at the end of “Mission 2” of the earth/soil topic on www.kniffelix.de in the community area. You can see your upload once we have checked if you have considered all Kniffelix rules like, that there are no people on pictures or insults in texts.

Knowledge-Box: Water Absorption of Soils

What does soil consist of?

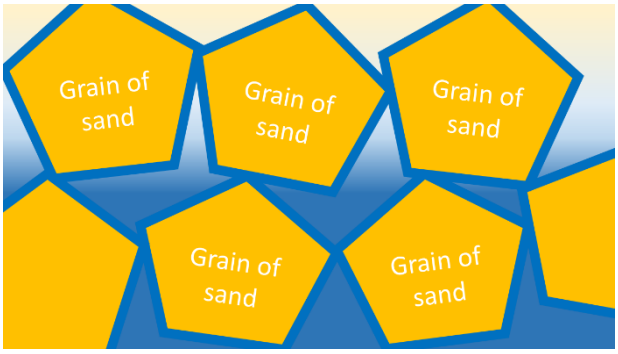
There is a lot in our soil: On the one hand, it contains abraded rock. The rock can take the form of coarse stones, gravel, sand and even fine grains of clay. On the other hand, soil is made up of dead, decaying plant matter such as withering leaves, air and water. The dead organic material in the soil is also known as humus.

How much water can soils absorb?

Water seeps through airy gaps in the soil. Some of the water sticks to the soil particles. The more contact the water has with the soil particles, the better it adheres to them. Among other things, the grain size of soil particles has an influence on how much water a soil can hold. The soil types sand, clay and loam differ in terms of their grain size. They can store water to varying degrees:

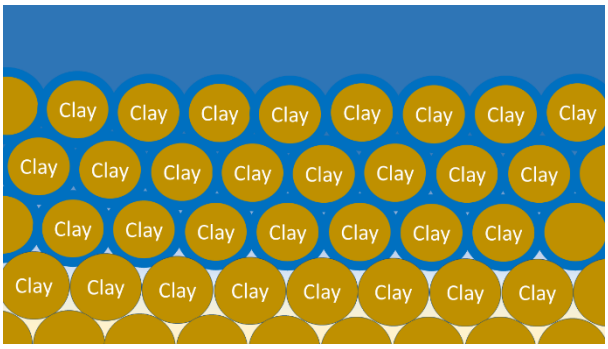
Sand:

Grains of sand are up to two millimeters in size. A lot of air can accumulate between the coarsegrained sand particles. The many airy cavities allow water to seep through quickly. The water has little contact with the sand particles so that it cannot adhere to them. Therefore, a plant has little water available in sand, because the sand stores it poorly. In addition, sand is well aerated due to the cavities and furthermore heats up quickly. Therefore sand can dry out quickly, and so do plants planted in sand.



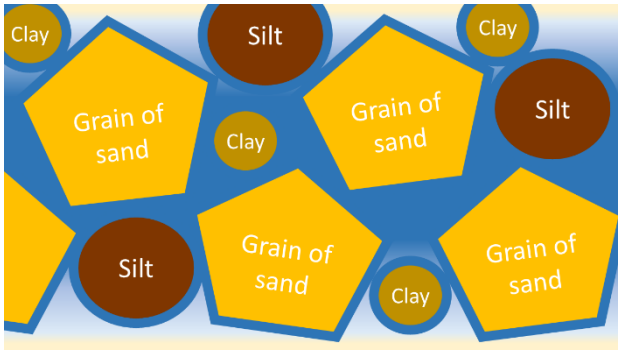
Clay:

Clay grains are so small that they cannot be seen with the naked eye. They have a maximum size of 0.002 millimeters. The fine grains are so close together that water has difficulty passing through. Therefore, water easily builds up on top of clay and does not pass through it. The closely spaced fine grains form a large surface area. The water has a lot of contact with the clay grains it reaches. It therefore adheres to them very well. However, the clay grains hold the water so well, that the roots of the plants have difficulty sogging up the water out of the clay. This is why the term “dead water” is used: water is present, but plants don´t benefit from it easily. It´s not accessible to the plants and remains in the clay.



Loam:

Loam is a mixture of sand, clay and so-called silt. Silt grains are soil particles with a size of 0.002 to 0.063 millimeters. Due to the mixture of different grain sizes, loam can hold more water than sand, but is not as impermeable as clay. Loamy soils are therefore good water reservoirs. Plants have enough water available here.



And what influence does humus have on the water absorption capacity of a soil?

It is not so much the size of the humus particles that is important, but another effect occurs here: the decaying plant matter can surround itself with a water shell and store a lot of water due to this capability. In this way, the humus in soil soaks up water and can gradually release it back to the plants. If humus is mixed into the soil, its ability to store water can be increased. This is good for plants needing water regularly.