Teacher's manual/Experiments in workstations
'Experimenting with water'
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Teacher's manual/Experiments in workstations

Experimenting with water

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With work-sheets

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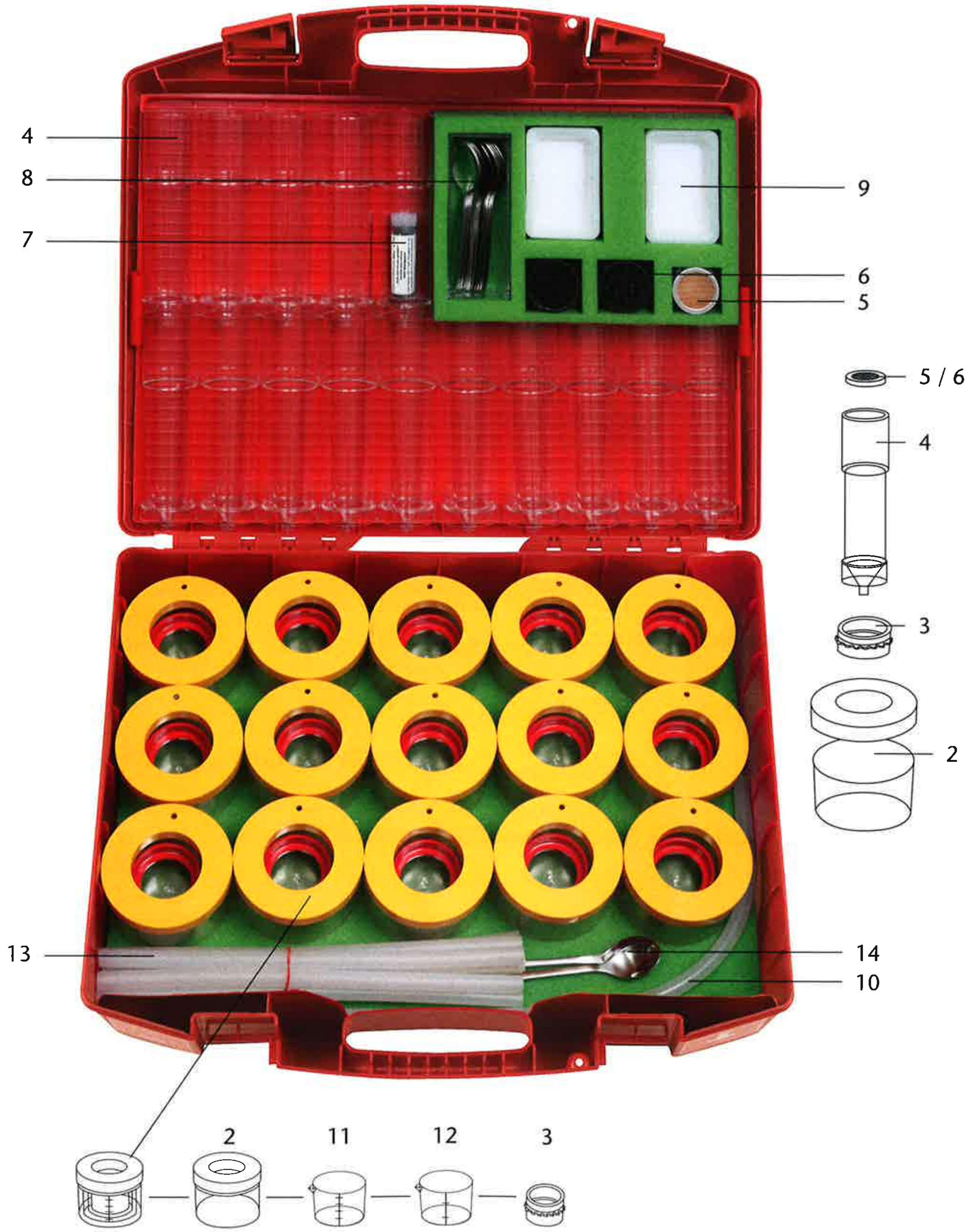
Content

Science box 'Water purification'



Teaching topic "Water purification"

Illustr.-no.	Qty.	Description	Order no.
–	15	Filter set-ups, consisting of	13103
2		• Filter bowls with lids	13111
3		• Push-on connectors for filter tubes, red	13120
4		• Filter tubes, transparent	13138
5		• Copper wire gauzes	13146
6		• Plastic grids (strainers), black	13154
7	1	Dye, blue (Food coloring E 132)	12913
8	15	Spoons, metal	13197
9	15	Germination dish	13278
10	1	Connecting tube, transparent, 65 cm	13219
11	15	Plastic beakers, 250 ml, with graduation	13162
12	15	Plastic beakers, 125 ml, with graduation	13170
13	7	Connecting tube, transparent, 30 cm	13200
14	2	Spoons, metal, 22 cm	13198

Enclosed printed material

–	1	Teacher's manual/Experiments in workstations "Experimenting with water"	3180261
–	1	Storage plan "Water purification"	318023

Experimenting at learning stations: A way to child-oriented learning

'Experimenting at stations' follows the principle of learning at stations. It is, however, designed for the special needs of primary school concerning experiments for pupils: to avoid risks some steps have to be presented more thoroughly, since students carry out all the experiments without the help of the teacher.
With the science box 'Water purification' and the worksheets from this workbook you can set up up to 24 different stations according to your objective, all of which have been proven in teaching. It is also possible to confine yourself to a selection of contents and offer stations on only one specific subject area. It is crucial that **every** pupil has the chance to select and work on his/her station.
To a large extent pupils should have the opportunity to decide whether they would like to work on their own, with a partner or in a group. However, considering learning theories it is especially advisable to work with a partner. The stations should be showcased in the classroom a couple of days beforehand and some of the crucial stations presented on the first day. The overview (p. 18) should be used. For the first encounter with the material it is recommended to select the most important stations and assign them specifically or draw.

Experimenting at stations and 'opening the classroom'

Although the teacher sets the range of the stations in advance, the pupils nevertheless have the opportunity to choose from a wide pool of possibilities.
They can

- choose a station based on its content or its required form of working,
- set the order and the revision (!) of stations within the bounds of range or decide on the dwell of time at a station,
- opt for the form of working and form of help,
- contribute to the range of possibilities by creating further stations with material that they brought from home.

At some stations, parents or other classes can be included. This combination of worksheets and materials for experiments enables you to open up your classroom accordingly. **You** decide to which extent you are willing to open up.

Principles on experimenting at stations

- overview of the entire subject matter,
- goal orientation (knowing and pursuing goals),
- activity-oriented learning (learning with the mind, but also with 'heart and hand')
- moving while learning,
- linking of knowledge,
- age-appropriate responsibility for one's own learning and dealing with learning material,
- promoting independence and own responsibility by fulfilling the demands at school independently as well as verify one's results and following through on something (!),
- favourable learning atmosphere,
- individualizing (see above range of possibilities),
- avoidance of taxing and non-taxing demands,
- you win time for individual help, correction, reinforcement, and help.

Hints for working in the classroom

Advice for working with the material

For the project 'Experimenting with water' you need the experimenting box '**Water purification**'
(Cornelsen Experimenta, Holzhauser Str. 76, 13509 Berlin, Germany, + 49 30 43 59 02-0, www.corex.de)
as well as the required material mentioned below (p. 12).

All worksheets with this symbol should be copied. Some worksheets have to be copied, for the pupils have to work with them and put them into their 'Book on water' which they produce during the project. Others have reading exercises and should be copied for partner work e.g. the letter of the authors "Dear children!" (p. 16). A third kind of worksheet has to be copied because the pupils have to cut something out.

Subject matter and language

An important responsibility of primary school is the formation of concepts. Matter and language have to be connected. Experimenting with stations provides this opportunity through individual discussions. In addition, three more measures help achieving this: partner work, presentations, and the 'Book on water':

1. **Partner work:** Although the choice of the social form should lie within the responsibility of the pupils, partner work is preferable. It facilitates the discussion about observed experiments and their results most effectively.
2. **Presentations:** Within each working stage on a station a presentation phase should be integrated. It can be included at the beginning, at the end or in the middle of the working stage. At this point one or two pupils can present up to two results. They can show and explain what they have done and found out. Next to the verbalization of the phenomenon, the ritual has two positive effects: First, the audience develops some interest in the presented station. Second, the teacher can choose 'the presenters' (in time), making sure that the important stations are presented one at a time. Consequently, specific points can be connected and accentuated. Furthermore, teachers can mark their important stations e.g. with self-adhesive pads.
3. **The 'Book on water':** Due to its free form it is very popular with the pupils. They can replenish it at home with pictures and collages.

Organizing the stations

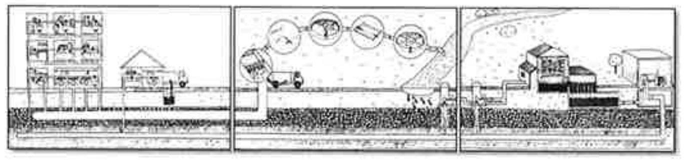
Put as many stations on display so that each child can find its own. The optimum would be to offer as many stations as there are pupils. If this is not possible in terms of content or economic reasons, you can put up the same station at two different spots or lay out the material of the same station numerous times. It is also possible to construct specific stations from the start as partner or group work activities.
It is recommended to copy **all** worksheets and file them into transparent poly pockets with the station's according number on it. This way, worksheets can be returned if needed.
The 'hidden answers' are revealed when the upside down written words in the foot note are folded back. You should discuss with the pupils how these notes can be used meaningfully.

The stations should be spread out in the classroom, for example on the window-sills and shelves or put up on walls within reach. It is also possible to display them in a suitable spot like a buffet. It is important that an unhindered overview and free access are guaranteed. The responsibility of taking care of the experimenting tools is to be given to two 'experts'. They keep an eye on the materials being complete, available, clean, and dry.
The required materials should best be kept in small buckets ('material corner'). To prevent scattering you can additionally put them into plastic tubs. For the disposal of water an empty bucket should be supplied. Only pupils who have been chosen beforehand are allowed to empty it. Some rags should also be found in the material corner. Especially in the first couple of times, it is necessary to schedule enough of time for cleaning up, since the pupils are inexperienced.
Experimenting at stations can be carried out in one lesson or in an entire unit. Then it is conducted over a couple of weeks and worked on daily. Since the project plays greatly into other learning fields, the project is also continued in classes taught in the mother tongue to facilitate language competences. The worksheets train the skill to extract meaning while reading and original writing intensively.

In many classes 'Experimenting with water' has been put up over a period of about three weeks and used daily as a constant arrangement in the classrooms. In assembling the stations (by setting up the 'material corner' and the stations, as well as the worksheets) only once and the pupils getting used to handling and organising the material as well as ritualizing reports, the economic and positive learning atmosphere had room to unfold. Most classes have been presented with all stations at once, others with single stations step by step. It was observed that alternating 'real' station work and some lessons when the entire class works together, can be productive. 'Experimenting with water' was successfully tried in the second semester of 3rd grade up to 4th grade.

Basics on subject matter

The following descriptions refer to the free content material of the Federal Association of the German Gas and Water Industry (BGW – Bundesverband der deutschen Gas- und Wasserwirtschaft e.V.).
In the illustration, which the children construct from worksheet C6, the different phenomena on water are depicted in a simplified way. The poster demonstrates the connections very impressively. It not only depicts the circle of water humans use, it also clearly shows in which way our experiments relate to reality. We suggest that you observe the following passages on the poster.



1. Raw Water
The raw water which water works process into drinking water derives from the ground (ground water) or rivers, dams and lakes (surface water): 65% is ground water, 27% is surface water. Only 8% is spring water. In relation to the project 'Experimenting with water' it is important to remember that spring water is nothing more than ground water emerging and that part of the surface water is produced only after it has seeped away. This fact gives reason to comprehend the filter effect in simple experiments.

2. Ground Water
For the most part our drinking water derives from groundwater (regional differences, however, have to be taken into consideration). Ground water is created when rain water seeps away into the ground. It seeps away through the aquiferous sand and gravel and accumulates where it meets water-impermeable layers (clay, marl). This procedure takes a long time; the rule of thumb is that about one metre takes up to one day. The layers which the water passes can be one metre or one hundred metres thick. On average the water 'travels' approximately 50 days. This way the soil layers treat it naturally. Collector wells pump up the water from about 30 m; vertical wells from a depth of almost 500 m.
When aquiferous and water-impermeable layers take turn, this is called multi-aquifer formation (groundwater reservoir). It can reach the depth of several hundred metres and be connected with each other interrupted by water-impermeable layers.

Water absorbs natural substances e.g. calcium carbonates or iron traces, while it seeps away through the ground. However, it also absorbs chemicals (e.g. residues of over-fertilization) or oil which ended up in the ground.
The yield of groundwater occurrence depends on the amount of rainfall and on the subsoil. Limestone, for instance, can hardly store water. Depending on the region, both factors can be very different as well as the accumulation of groundwater occurrence.

3. Surface Water
Bank infiltration and infiltration: Rivers enrich ground water naturally for their water seeps away into and next to the riverbeds, uniting with the 'real' ground water. Wells in proximity to rivers are, therefore, more productive than those farther away. Since surface water of rivers is filtered through the soil layers when seeping away, it is called bank filtration. The process can be artificially enriched by diverting parts of the river water into infiltration basins, that way creating an artificial groundwater recharge (infiltration).
In both cases a mixture with the 'real' ground water and the seeped away surface water is generated with pumps in proximity to the river. Bear in mind that despite all legal regulations it is not always possible to ensure that the river water stays clean from illegal discharging as well as the sewage treatment plants also ejecting the treated wastewater into rivers.

Water from dams and lakes: A lot of regions in Germany depend on drinking water from dams because the groundwater occurrence is not sufficient. They can be found, for instance, at the Ruhr, in the Bergisches Land, and in the Harz Mountains. Lake Constance is best known amongst lakes; water is taken from it at a depth of 60 m.

4. Long-Distance Water Pipelines
Where neither ground water nor surface water is available in sufficient amounts, the water demand has to be covered by long-distance water pipelines. An example is the region around Stuttgart. It is connected by a long-distance pipeline of 226 km to Lake Constance.

5. Water Works
Water works "do not produce water" – that is what is written in the text for the pupils. They 'only' treat the water and pump it into the supplying pipes– for each

How to use this teacher's manual

citizen uses 126 litres of water on average each day.
During the **treatment of the ground water** natural substances (iron, manganese, calcium carbonate, carbonic acid, and minerals) which affect the taste of the water or which deposit in the pipes are extracted to a large extent. To accomplish this, it is either aired through fine spraying in open spaces or is brought in contact with pure oxygen in closed-up containers. In both cases the oxygen causes the iron and manganese, which dissolves in the water, to generate small flakes which can be disposed of later on through sand and gravel filters. The quality of the drinking water is often so good that it is not necessary to add small amounts of chlorine to protect it from microbial contamination. Since drinking water demand varies over the course of day, it is collected in drinking water containers.
Treating surface water is a complex process. Surface water (in bank filtration as well as in dams and lakes) has some nitrogen compounds, heavy metals, salts, and hydrocarbons which despite all legal regulations get into the stretches of water. These substances can neither be held back while seeping away into the ground nor through the described methods of water treatment. This is why this raw water has to be treated with e.g. ozone and then diverted through special filters which are filled with activated carbon. A disinfection of water can follow this, before it is delivered as drinking water into households.
It is allowed to say that in principle the treatment of ground water and surface water is similar: through contact with air/oxygen or rather ozone those substances which need to be extracted are converted in a way so that they can be filtered out. The filters (gravel or activated carbon) for their part have to be cleaned from time to time.

Note:
Some of the following technical depictions follow publications of regional water companies (here: Berlin, Germany). We suggest that you contact the water suppliers responsible for your school region and ask them for informative material and especially for the answer which station B2 needs: Where does your water works obtain its raw water from? You should also find out the costs for one cubic metre of water (if necessary divided in drinking water and wastewater). You should also know which role water towers play in your local supply network (see station B4, p. 40). Often there are opportunities to visit water works, too.

6. Network of pipes
Drinking water is directed from water works into households. With long-distance water pipes this can be quite a distance. The required pressure is either generated by water towers or pumps. The functioning of modern pumps can be compared - if simplified - with the process of spin driers. Regarding water towers the proposed experiment gives the following explanation: Following the principle of communicating vessels, water rises in all pipes to the height of the water level of the container (water tower), which is situated at the highest spot, therefore, generating the required pressure. First, of course, the water needs to be pumped into the water towers; however, the required technical expenditure is lower than holding an entire supply network under (pumping) pressure.
To be able to cut off the underground supply network for repairs, construction works or burst pipes, valves are installed. In Germany the signs look like this: blue signs with lettering A, V, or W indicate where the slide valves can be found. Similar signs – white with a red rim – indicate hydrants. First and foremost they help the fire brigade in emergencies. For the firemen to be able to judge how powerful the pipe is that leads to the hydrant, its strength is indicated next to the H. 'H 150', therefore, means that the supplying pipe has a diameter of 150 mm. How do such signs look like in your country?
Another network of pipes is responsible for the disposal of wastewater. In big cities there are underground sewage systems which collect the wastewater and redirect it. This network has also pumps and slide valves.

7. Sewage Treatment Plant
First of all, let us follow the comments at station C1 (p. 43) and try to imagine what it is that wastewater transports. We visit a large supermarket. The amounts of toilette paper, detergents, soaps, scouring agents, shower and bath articles we can find on the shelves of a single supermarket! Soon they will all end up in the wastewater. Since these articles are being produced for this specific kind of use, we can assume that the manufacturers tried their best to make them degradable. Toilette paper, for instance, soon disintegrates in the wastewater into fibres. It is, of course, still a component which has to be eliminated at the treatment plant; however, it neither clogs the pipes nor does it stay on the rake. Besides articles, which have been produced in accordance to their future disposal, there are also those which are more difficult to dispose off and which have been thrown in by mistake or thoughtlessly.

It is important to consider these facts because the water works direct the treated water back into the natural water cycle (river). We might encounter the treated water as raw water again for instance through bank filtration. It is, therefore, essential that everybody 'gives water works a realistic chance' in extracting all contamination. The fact that we can only contribute to a certain degree to that, is shown by the following interesting consideration, especially for adults: what happens to the ingredients of medical drugs that a body excretes?
Besides the natural water cycle (evaporatoed water, cloud formation, precipitation, evaporated water, ...), there is also an artificial cycle: ground water – drinking water – surface water – ground water. Pupils at primary level can understand this, even though it is rather rudimentary (see station C6, p. 49). They establish a basic understanding about why there are drinking water reserves, why chemicals must not be thrown away into the drain or leaking oil tankers are great environmental problems. Grounds for discussing the mentioned cycle are the following stations 'How water gets into and out of the ground: Let's sink a well' (p. 26), 'How did/does drinking water get into houses in the past/today? How did/ does it get out?' (p. 38) and 'Where should wastewater be piped to?' (p. 49). All three stations are specially designed in a child-friendly and attractive style. Moreover, the easy and fascinating experiments in A4 (p. 23) prepare the ground for understanding why ground water needs to be protected. We remind of the famous speech of Chief Seattle in front of the President of the United States (1855): "Whatever befalls the earth befalls the sons of earth. If men spit upon the ground, they spit upon themselves. - This we know; the earth does not belong to man; man belongs to the earth. All things are connected."

Stages of treatment in the treatment plant

1. The rake: all coarse contaminations are held back here. Afterwards they are drained and directed to the disposal side or refuse incineration.

2. The grid removal tank: it consists of long channels. At a flow velocity of 30 cm per second coarse minerals like sand, gravel and small stones sink to the bottom. Here they are pushed together, drained and disposed off.

3. The primary clarifier: here the water flows even slower (1.5 cm per second). The fine particles, which are able to swim (for the most part fat), accumulate at the surface of the water, others sink to the bottom. Here they are pushed into a funnel by machine and pumped to the sludge treatment. The swimming particles are removed from the surface.
– Until now the technical principles are imitated in easy experiments. The following processes of the biological treatment are beyond illustration. –

4. The aeration tank: the organic whole substances which are dispersed in the water (e. g. faeces) as well as phosphates (e. g. from detergents) and nitrogen compounds are broken down. The breakdown is carried out through bacteria and other microorganisms, which form the activated sludge. The first part of the aeration tank is low in oxygen or oxygen-free. This way an increased biological removal of the phosphates from the wastewater is possible. Afterwards a lot of oxygen is introduced into the wastewater. This is carried out by blowing in compressed air. Supplied with oxygen and food (which consists of the dispersed substances), the bacteria can reproduce in a ratio of one to one million in 24 hours.

5. The secondary sedimentation tank: here the activated sludge from the aeration tank has several hours to sink down to the bottom (the wastewater is now treated and directed into rivers). The set sludge is pushed into sludge funnels by circulating scrapers. For the most part the sludge is transported back into the aeration tanks. The additional sludge which is created through the reproduction of the microorganisms ... is either drained and burned or digested in digestion towers. The digested sludge is also ... drained and composted or dried. The illustration of the process at sewage treatment plants refers to the publications of regional waters suppliers, here Berlin.

Note: 'Septic tanks'
Only few German households are not connected to the wastewater system of their community. The wastewater is collected in a container which is set in the ground. It has to be absolutely waterproof and emptied as required. This is carried out by a company which brings the wastewater to a treatment plant (see C6: 'Where should wastewater be piped to?', p. 49). Sometimes there is also a 'three-chamber system'. Here the 'grey wastewaters' – these are wastewaters from the washbasins, tubs, showers and washing machines – are roughly treated following explanations 2 and 3, and with rainwater directed into a brook or other. Faeces are separated from this and have to be disposed of through a specialized company. Such constructions are not being approved for new buildings anymore.

Shortage of water in other countries, exemplarily represented by Senegal and Kenya

It is generally known that countries south of the Sahara desert suffer the most from shortage of water. On average only one in two inhabitants has sufficient drinking water. Referring to the World Health Organization (WHO) a person needs at least 20 litres clean water daily. In Germany, 126 litres per person are calculated. If the country has less than 1000 m^3 of renewable freshwater per head and per year at its disposal, water shortage is ascertained. There are, however, countries which are referred to as the most arid countries on earth though, nevertheless, having enough freshwater at their disposal. They lack the necessary infrastructure and funds, in order to obtain water through groundwater drilling, desalination of seawater and wastewater treatment as well as distribute it fairly. This includes above all countries in the Near East. The supply of drinking water of a big continent as Africa has to be looked at more discriminately. The rural population is here especially at a disadvantage. Traditionally, the task of getting water falls to girls and women. They have to cover far distances on a daily basis in order to get 10 to 15 litres of water at a watering hole. Carrying water is an enormous physical exertion. It takes the water carriers up to six hours to do that. The water is transported in calabashes or buckets on the head. Probably this position is less tiring than carrying them on one shoulder. Water carriers in the Middle Ages distributed the weight by laying a yoke on both their shoulders and hanging two buckets on it. Water shortage contributes to the fact that girls are not able to go to school. Contaminated water and missing sewage water disposal also leads to spreading of pathogens and parasites. Diarrhoea diseases, worm infections and typhus, for instance, are passed on through water.
Finally, meagre resources are again and again an increasing reason for conflicts between states which procure the water from the same source. In year 2002 all over the world 1.7 billion people had no access to clean drinking water!

Material requirements

Explanations on filling the 'small aquarium' at station A6 (p. 26) are not included here, since it is not mandatory.

1. Soil Samples

- **soil:** a bucket of 5 litres filled with loose, garden mould (e.g. potting compost).
- **sand:** a bucket of 5 litres filled with sand generally used for sand pits; the sand has to be thoroughly rinsed (e.g. in a strainer or as described in station A4, p. 23), so that the filter effects are not impaired because it has fine dust left.
- **gravel:** a bucket of 5 litres filled with coarse gravel which, for instance, is used for aquaria; the gravel has to be rinsed thoroughly, too (see above), so that the filter effects are not impaired because it has fine dust left.
- **clay:** 2 kg of clay used for arts education (very fat, smooth consistency) or clay found in the environment (a little bit sandy, rather tender consistency); it has to be kept wet so that it can be filled into the tubes and stay waterproof up to the rims. The clay can be kept in a moistened plastic film.

2. General material

- (a little) detergent,
- (a little) cooking oil,
- salt,
- cotton wool,
- in water dispersed toilet paper (C3),
- fine stripes made from a plastic bag (ca. 0.5 cm x 3 cm) (C2),
- drinking straws,
- brass fasteners,
- paperclips,
- cardboard rolls (like toilet paper rolls),
- coins,
- tape,
- ice cubes (D2),
- toothpicks (if needs be matches) (D2),
- transparency (or enlargement) of B3,
- if necessary coffee filters (see A4),
- a spike.

3. Material from the science box 'Water purification'

- filter set-ups: consisting of filter bowls, lids, push-on connectors, filter tubes, copper wire gauzes, plastic grids (strainers), beakers (125 ml, with graduation), beakers (250 ml, with graduation);
- germination dishes;
- spoons;
- connecting tubes (transparent);
- food colouring (dyer);

Box 'Water supply' can be used additionally. It has demonstration tools which belong to station B4.

Practical advice

- In order to fill the tube with clay, it has to be kneaded into a small ball. The grid is positioned into the tube first, then the clay. With a long pencil it is pushed down. The rim of the clay can be high, so that the water cannot flow past the rim of the clay ending with the rim of the tube. Since the clay dries, it must not remain in the tube at the end of the lesson. It can be easily removed with a pencil by pushing against the grid from below.

There are different ways to carry out the experiments:

- Pupils can fill up the tube each time and 'recycle' the materials which were treated with clean water, and dispose of the ones which were 'contaminated' with salt, oil, detergent and colouring in the garbage.
- Or: the experiments with soil, sand, and gravel are 'built up' only 'once', which means filling up the tubes according to the suggested experiments and reuse them again and again. **Alert:** this is not possible with clay. It dries up and shrinks, making it possible for the water to flow past the sides.
- This combination has also proven itself: part 'done' set-ups of experiments (e.g. the 'tower' in station A3, p. 22), part 'new' set-ups (e.g. filter effects in station A4, p. 23 f).

Advice on disposal:

Since all used material usually ends up in the domestic wastewater (cooking oil, detergent, food colouring, and salt) or rather in the domestic waste (sand, gravel, and soil), they can be disposed of in such a way.

Notes

Introduction no. 1: Dear children . . . . *page 16*

This 'letter' can be read for instance with a partner and afterwards discussed with the entire class. Experience shows that children like to discuss the statement "No life without water" and find out the truth behind it very quickly. The way of proceeding, which the text mentions, is important for conducting of the entire unit. Here is some background information:

- Partner work is preferable, for most experiments are more successful that way, material is used more economically and it facilitates discussion.
- Reading of the worksheets should be accomplished at the desks where pupils work daily (not while standing at the stations' desk) to ensure that extraction of meaning and understanding of content is guaranteed as well as the preparation for their work is done correctly.
- Worksheets and material stay on the desk (regardless of the water) while taking notes in the 'Book on water' to support correct spelling and drawing.
- The expert system relieves you as a teacher. You can either write down the names of the experts next to the stations or pin clothes pegs with their names on it to the according station. Each station should not have more than two experts.
- Especially, in the first lessons of the unit, cleaning up will take longer. Some classes calculated ten minutes for this but became faster. Others established a 'water chore' as in art classes.
- The pupils in charge of the box are indispensible. Throughout the entire unit they are responsible for every experimenting tool being completely put back in its place and taken care of. Here, it is important to handle the supplies sand, gravel, soil, and clay very carefully and dry the single parts. The clay has to be kept wet. Sand and gravel have to stay clean, if you want to observe its filter effects.

Introduction no. 2: My book on water . . . . *page 17*

The report book 'My book on water' has been extremely successful with this kind of teaching and learning. In order to guarantee a correct spelling, firstly the pupils have to keep the worksheets at the table and secondly pay attention to the 'hidden answers'. Thirdly, you can provide the class with a word collection on water. This collection should be positioned at a central spot in the classroom and contain all words that you deemed important while looking through the worksheets. You should complete the collection with words that the pupils are asking about during their work.

Introduction no. 3:
Overview of the workstations . . . . *page 18*

Each child receives a copy of this worksheet. This way when introducing the subject topic, you have an overview which facilitates discussion and gives a first orientation. Later on it documents the progress of work for every station that has been completed has to be ticked. This worksheet is kept in the 'Book on water'. It is also helpful to enlarge this overview and put it up on the wall as a 'station'. Here the children can indicate with initials or abbreviations which station they have already completed. When everyone can see who has completed which station, it is much easier to get help, ideas, and have reasons for discussion.

Station A1: Rainwater! Where does it go? . . *page 19*

At a rough estimate one third of the total rainfall seeps away into the ground, one third streams to lakes and such, and one third evaporates. This distribution is theoretical, since it depends on local e.g. climatic conditions. It shows, however, that all three processes are equally important. Station B1 illustrates the seeping away, which is researched through experiments at other stations. The assignment instruction is as important as the hidden answer.

Station A2:
Different types of soil: The big test. . . . . . . *page 20*

These experiments are fundamental. They lead to definite results, if you remember that the clay can only seal the tube when it is damp and positioned correctly (see page 12). Should you decide to reuse the assembled experiments, then this will only be possible with sand, gravel, and soil. The clay shrinks when drying and lets the water through past the sides.

Station A3: Drilling deeply into the ground . . *page 22*

This experiment fascinates children especially, if they have the opportunity to switch the tubes. This way they can get closer to nature and experience it more realistically, since soil layers appear in different orders. The water which accumulates in the gravel above the clay, depicts the ground water supplies in the 'aquiferous' types of soil vividly.

Station A4: Ground water is clean, if not .... .*page 23*

Please, use only the powder labeled 'food colouring' or 'dyer'! It should be obvious that it is still unfit for consumption. Remind the children that the coloured water must not be drunk (due to potential germs). Licking off the colour from the fingers, however, should be harmless. Three things should be remembered at station A4 – worksheet no. 2:

- You should mix the coloured water yourself. Portioning the very sensitive powder requires a steady hand.
- Since the saltwater needs to be tasted, it is advisable to rinse out the gravel under running water.
- Those who have reservations (adults or children) despite the rinsing, can follow the instruction on the coffee filter. It leads to the same results, however, conveys a wrong picture.

The results of the series of experiments give reasons for protecting at least those areas from where drinking water is derived.

Station A6: How water gets into and out of the ground .... *page 26*

The children are not expected to fully understand the formation of ground water. The picture is enough. Nevertheless, during the trial of this book different groups of pupils brought a suitable container and filled it according to the sketch. They were supported by their parents. If this happens in your class, please, remember: the 'aquarium' must not be big! An inner bottom surface in the size of a regular sheet of paper is enough. Even then, a lot of clay, sand and gravel fit into it. The filled container will be *extremely* heavy. Therefore, fill it up only on the spot.
The experiment on worksheet no. 2 depicts the sinking of a well pretty well. The drill pipe and well pipe are easily made. Our 'well pipe' becomes soggy very quickly.

Station A8: Too much water .... *page 30*

This text depicts real events and is in every respect authentic! The sketches are based on original photos. Only the explanations which are given by the mother are extremely simplified. Nevertheless, she gives an accurate account of the key message.

Station A9: Too little water .... *page 32*

This station shows two fictive but realistic examples about water supply: one child describes how difficult and laborious it is to get water from the village market for its family. The second child has to walk long distances to get water for its family. Both examples indicate that due to unclean water there are frequently (diarrhoea) diseases.
Filling in the missing lines in the second letter, helps pupils to empathize with the children.
By providing factual information the second page demonstrates why the situation in the mentioned African countries is so desolate. In order to analyse the difficulties of procuring water in such an environment, a change of perspective is envisaged: how much time is needed for procuring water? How heavy is the procured water, and how much water do we consume per day? It is important that pupils understand the connection between rainwater, ground water, drinking water, and the costs for the pipeline network while presenting their results.

Station B1: It's not working without drinking water – pairs .... *page 34*

You can copy the cards, cut them out and put two sets with the worksheet next to the station. Alternatively, you can lay out the copied worksheets for each student, so that the students have the opportunity to put the pictures into their book or in an envelope and take it home.

Station B2: Do water works produce water? . .*page 36*

At this station you have to know which part of the picture corresponds with the *place of residence* of your pupils: is the water there coming from the ground water, a reservoir or a lake? Only the according part of the picture should be coloured. In order to prevent continuous questions from the children, teachers deposited an explanatory letter next to the station (opportunity for practising extracting meaning while reading).

Station B3: How did/does drinking water get into houses in the past/today? How did/does it get out?.............. *page 38*

It is best to provide the station with transparencies or enlargements of both worksheets. Concerning the rainwater disposal , the picture illustrates only *one* technical solution: rainwater is directed to the sewage treatment plant (combined sewer system). Another system which is often applied directs the rainwater separately from the sanitary wastewater from houses into storm water tanks, lakes, and rivers (separate sewer system).

Station B5: Where are the pipes? .... *page 42*

Some teachers look for the signs themselves and take pictures in the neighbourhood.

Pupils can invent their own signs based on the examples, present them to the class, and let them interpret the signs. Do not forget the measuring tape.

Station C2, C3:
Let's try to treat wastewater .... *page 44,45*
Station C5: A sewage treatment plant .... *page 47*

The basic principle of mechanical sewage treatment can very well be understood with the experiments. As soon as the children have carried out one of the experiments, they are to find the correct station in the overview about the sewage treatment plant (station C5: A sewage treatment plant treats wastewater).
Note: Children tend to add more 'waste' into their wastewater mixture. Paper is especially very popular. This, however, generates an incorrect picture: before paper can reach the sewage treatment plant, it dissolves into its elements in the 'real' wastewater (see 'Basics on subject matter' page 8). If children add it to their experiment, it will get stuck in their 'rake' – a factual incorrect result. However, it is possible to dissolve toilet paper like papier mâché in water: rip a couple of sheets of toilet paper into small pieces, throw them into a substantial amount of water and stir it. This watery mush can be used for station C3. In part it will sink to the bottom or accumulate on the surface. For station C3 it is suggested to use samples of material which get stuck in real rakes. These mimic elements of diapers and toiletries which, of course, should not be thrown away into the toilet but, nevertheless, end up there by mistake.

Station C4: The smallest creatures help treating wastewater .... *page 46*

This principle is of such importance to the wastewater treatment that although pupils cannot carry out the experiment themselves, it is necessary to provide information on its functioning.

Station C6:
Where should wastewater be piped to? . . . *page 49*

One can understand this 'booklet' only, after completing the essential stations about ground water formation, drinking water supply, and sewage water disposal. By executing the task and colouring the pipes, the children have an important insight: water from the sewage treatment plant streams into the river and by seeping away gets (partly) into the ground water (illustration 2). Since water works produce drinking water (illustration 3), the circle is completed.

Preface to station D1, 2, 3, and 4 .... .*page 51 – 54*

These stations are about fun, an encouragement to be astonished and talk about it, a training of observation technique and skillfulness. The physical explanations are not topics of the primary level. Experiments D1 and D2 are presented here thanks to *veolia water*, an international water company. You can find its products on the internet: www.veoliawater.com

Station D1: Floating paper clips .... *page 51*

This experiment is easy if the paper clips are dry and put down on the tissue as long as it is floating. Only this way the destruction of the surface tension at the positioning of the paper clip can be prevented. The paper clip stays on the surface of the water because the water molecules are holding the tension steady. This is due to the fact that the molecules at the surface can only bind themselves to the molecules on the side and below. The deeper lying molecules bind themselves to molecules all around.

Station D2: 'Ice Lolly'................. *page 52*

Ice floats, although it consists of water. It floats due to it having a lower density than water. Ice takes up more space than water which is frozen in it. Children can easily comprehend this: the ice extends over the edge of the ice cube container, where the water was frozen. Therefore, it is 'lighter'. The fact that only a small part of the ice cube juts out from the water is also very interesting.
The stick (toothpick, match) freezes to the ice cube because by sprinkling the salt on the surface of the cube the ice melts a little bit: a small 'puddle' appears in which the stick lies. Since the ice cube is much bigger compared to the water, the 'puddle' freezes immediately and encloses the stick.

Station D3: The coins in the beaker ...... *page 53*

No two bodies can occupy the same space at the same time: the mass of the coins displaces the water, whose amount is caught in the overflow vessel. Before that, however, something else can be observed: how the surface of the water tightens and spans increasingly (see station D1).

Station D4: The water magnifying glass . . . *page 54*

The surface tension was extensively explained in previous chapters. Here, again it plays a major role since it 'holds' the drop which lies on it 'together'. It appears as a magnifying glass. That drops are being held together to a certain degree can be observed at any dripping tab.

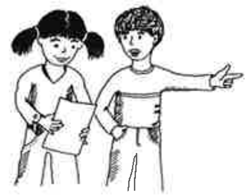
Introduction 1

C

Dear children,

Can we survive without water? Can animals or plants?
Is the assertion "No life without water!" true? Discuss it. You know a lot already.
You will find out more by reading and experimenting.
At the end, for example, you will know how ground water, drinking water, and waste water are connected.

This is how you use the worksheets the best:



1) Decide on a station (it works better with a partner).

2) Read the text carefully and
3) compare what you have read with the pictures. Discuss how you want to proceed.

4) Get the material and

5) work on the tasks.

6) At the end write and draw into your 'Book on water'.
7) Only then, you take the station's instruction worksheet and material back.

Have you been successful with a specific station? Then report yourselves as 'experts' to your teacher. Perhaps he or she will write down your names on the station's instruction worksheet. Then everyone knows: you can help, if there are questions.

Besides the 'experts' for the individual stations your class needs two helpers for the science box. They have to make sure that at the end of the class all the experimenting tools are at their spot and dry. Together with the teacher they ensure that these material are always available to the class: sand and gravel (both washed), topsoil, clay, oil, detergent. Besides, you should always have cloth and paper towels nearby. You definitely need a bin where you can tip the water into after the experiments.

Remember that at the end of the class you need time for cleaning up.

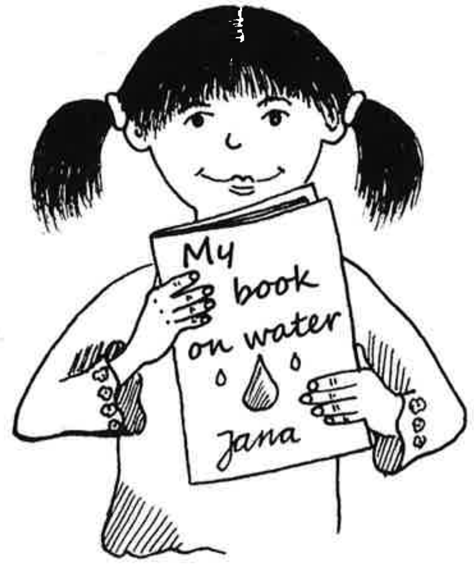
Best of luck wish you Nicole Lüders-Barrie
and Christian Hoenecke
(the teachers who developed these worksheets and tried them out with their classes)
(Anna Bitmann the translator)

By the way: A C on a station's worksheet indicates that you need a copy of it.

Introduction 2
My book on water

C

Create your own 'book' on water.
The book can be a big notebook or folder.
At the end it will contain everything you have found out about water at school and at home.
Write down your experiments and results.
Make big sketches of the experiments.
Stick in worksheets and pictures.
Check everything. The 'hidden answer' might help you. You can find them at the bottom on a lot of worksheets.



Write down on each worksheet:

- date
- headline of the worksheet
- your partner's name

Introduction 3
Overview of the workstations

C

Finished stations, I always mark with a ✓ !

Introduction

☐ Introduction no. 1 – A letter

☐ Introduction no. 2 – My book on water

☐ Introduction no. 3 – Overview of the workstations

A Ground water

☐ **1** Rainwater! Where does it go?

☐ **2** Different types of soil: The big test

☐ **3** Drilling deeply into the ground

☐ **4** Ground water is clean, if not …

☐ **5** A small hydrologic cycle

☐ **6** How water gets into and out of the ground: Let's sink a well

☐ **7** Let's make a revolving picture

☐ **8** Too much water

☐ **9** Too little water

B Drinking Water

☐ **1** It's not working without drinking water – pairs

☐ **2** Do water works produce water?

☐ **3** How did/does drinking water get into houses in the past/today? How did/does it get out?

☐ **4** Who generates the water pressure? How does water get into houses?

☐ 5 Where are the pipes?

C Wastewater

☐ **1** What is in the wastewater?

☐ **2** Let's try to treat wastewater with a 'rake'

☐ **3** Let's try to treat wastewater in a sedimentation tank

☐ **4** The smallest creatures help treating wastewater

☐ **5** A sewage treatment plant treats wastewater

☐ **6** Where should wastewater be piped to?

D Water Games

☐ **1** Floating paper clips?

☐ **2** 'Ice Lolly'

☐ **3** The coins in the beaker

☐ **4** The water magnifying glass

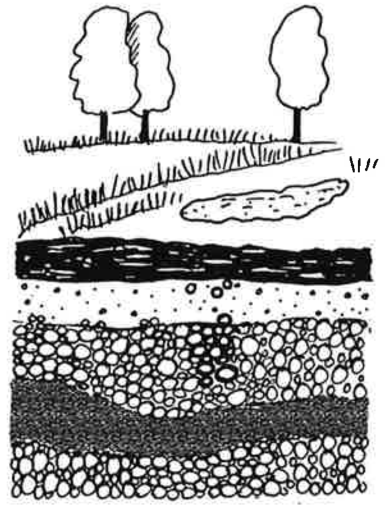
Rainwater! Where does it go?

C

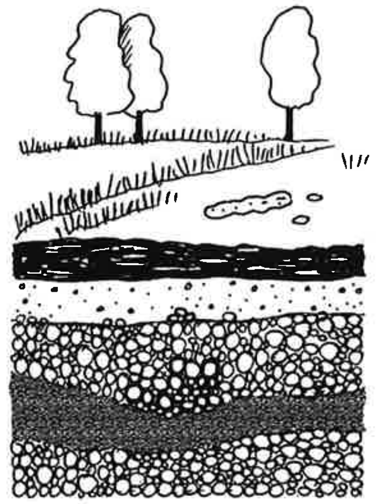
It has rained. Everything is wet. There is a large puddle on the field.
Our illustrator has thought about how the ground would look like, if it was cut like a cake.

1. You would see this:

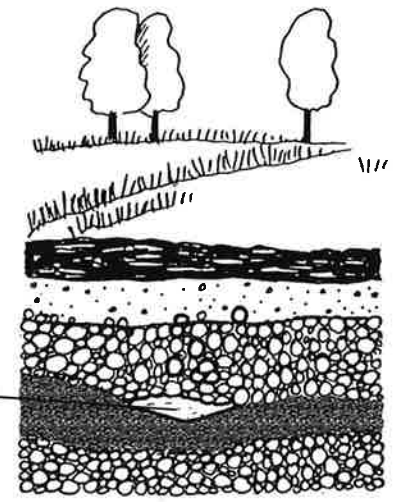
2. Later, it looks like this:



3. A little bit later:



4. At the end, when the puddle has disappeared.



- Colour the water blue in all four pictures.
- Explain what happens in picture no. 2 and no.3 by drawing in arrows.

The hidden answer: Fold back the answer. Don't look at it until you have finished the sheet.

A huge part of the water disappears into the ground. It seeps away! It seeps away through the topsoil, sand, and gravel, then stops at the clay. It accumulates! Now it is ground water. Your arrows have to show that! Part of the water has disappeared into the air. It evaporated. You can do an experiment on that: A5.

Different types of soil: The big test
Worksheet no. 1: Preparing the experiment

Have you ever dug a deep hole in your garden? Then you should know: on top is **black soil**. It is called **topsoil**. A little bit deeper you can find light coloured **sand**, later **gravel**. These are many small stones.
Digging even deeper, you can find solid ground. It feels like plasticine. That is **clay**.

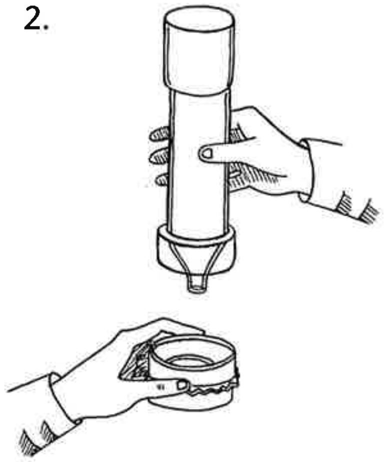
Have you ever dug a hole at the beach? Then you know that there is no black soil but a lot of fine sand. And a little bit deeper perhaps coarse sand or gravel.
Or was the gravel at the top?
You see? The ground is not everywhere the same. Besides that, there are also a lot of different colours: brown, red, yellow – sometimes lighter, sometimes darker.
There are almost white or black grounds, too.

But one is for certain: there are different types of soil on earth. And when it rains water covers the ground.

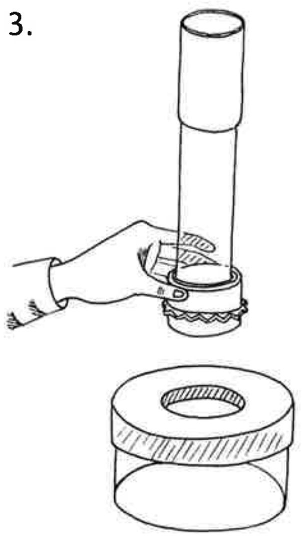
- What happens, when water meets gravel, clay, sand, and topsoil? Try it out. To do this, you need a container first. The pictures illustrate how to do it with parts from the box.

1.

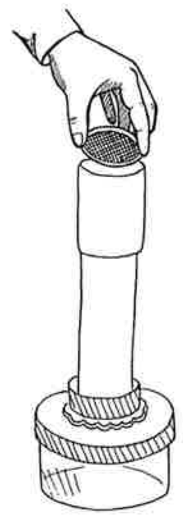
2.



3.



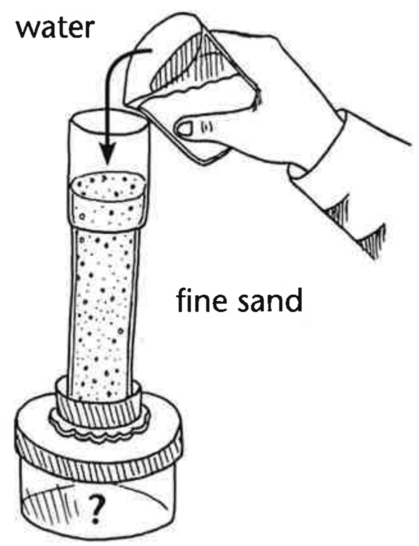
4. Do not forget the copper wire gauze (5)!



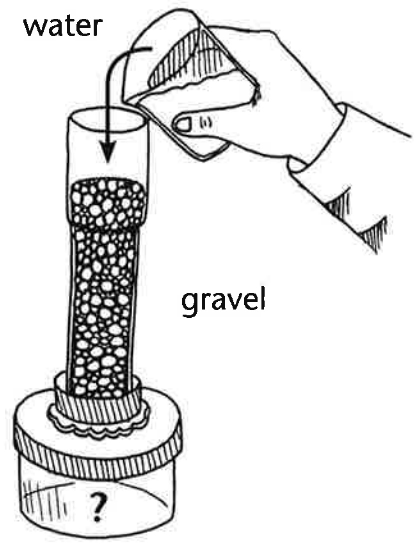
5. Fill the container with sand, gravel, topsoil or clay.

Different types of soil: The big test
Worksheet no. 2: Conducting the experiment

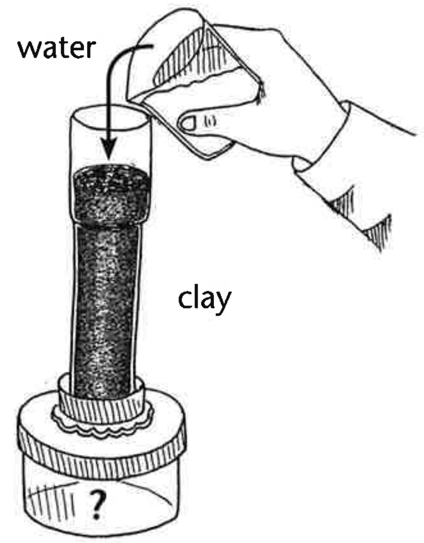
1.



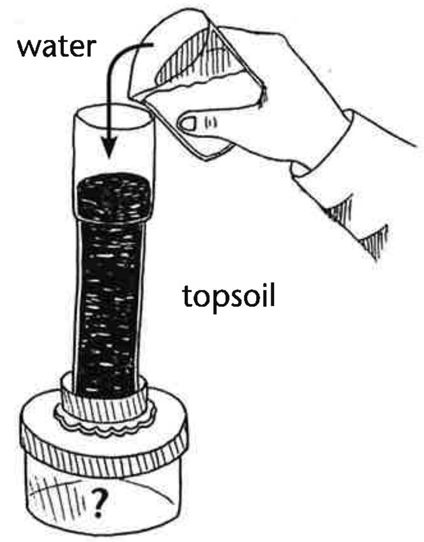
2.



3.



4.



- Transfer the four drawings into your 'Book on water' – without the hands. Draw into each picture what happens and where the water ends up.
- Write down your observations.

The hidden answer: Fold back the answer. Don't look at it until you have finished the sheet.

Clay does not let the water through. It is impermeable to water and accumulates it.
Topsoil, sand, and gravel are permeable to water.