Federal Ministry for the
Environment, Nature Conservation
and Nuclear Safety

WATER IN THE 21ST CENTURY

EDUCATIONAL AND INFORMATION MATERIALS

Note: This material was originally published in German and was designed for lessons for 12-16 year old pupils in Germany. It may therefore be necessary in some cases to adapt the worksheets to the situation in the countries where the material is to be used. To this end, the material is available for download free-of-charge on the Federal Environment Ministry's website at www.bmu.de/bildungsservice.

IMPRINT

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EDUCATIONAL MATERIALS OF THE FEDERAL ENVIRONMENT MINISTRY

Under the banner "Building technical and scientific problem-solving capacities through environmental and conservation-related topics", the Federal Environment Ministry publishes educational materials on priority topics such as renewable energies, climate protection and climate policy, the environment and human health, biological diversity, land use, phasing out the nuclear power programme, etc. in conjunction with the publishing house Zeitbild Verlag and the Department of Educational Science and Psychology, Educational Future Science Section at the Free University of Berlin. The materials build on the most recent findings in the field of educational research and on the model programme, Education for Sustainable Development.

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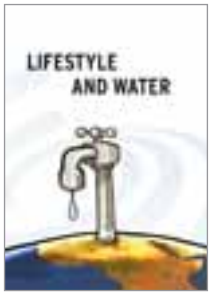
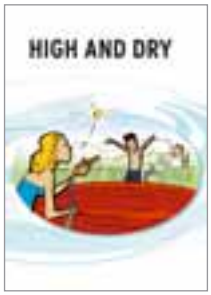
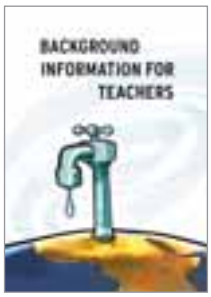






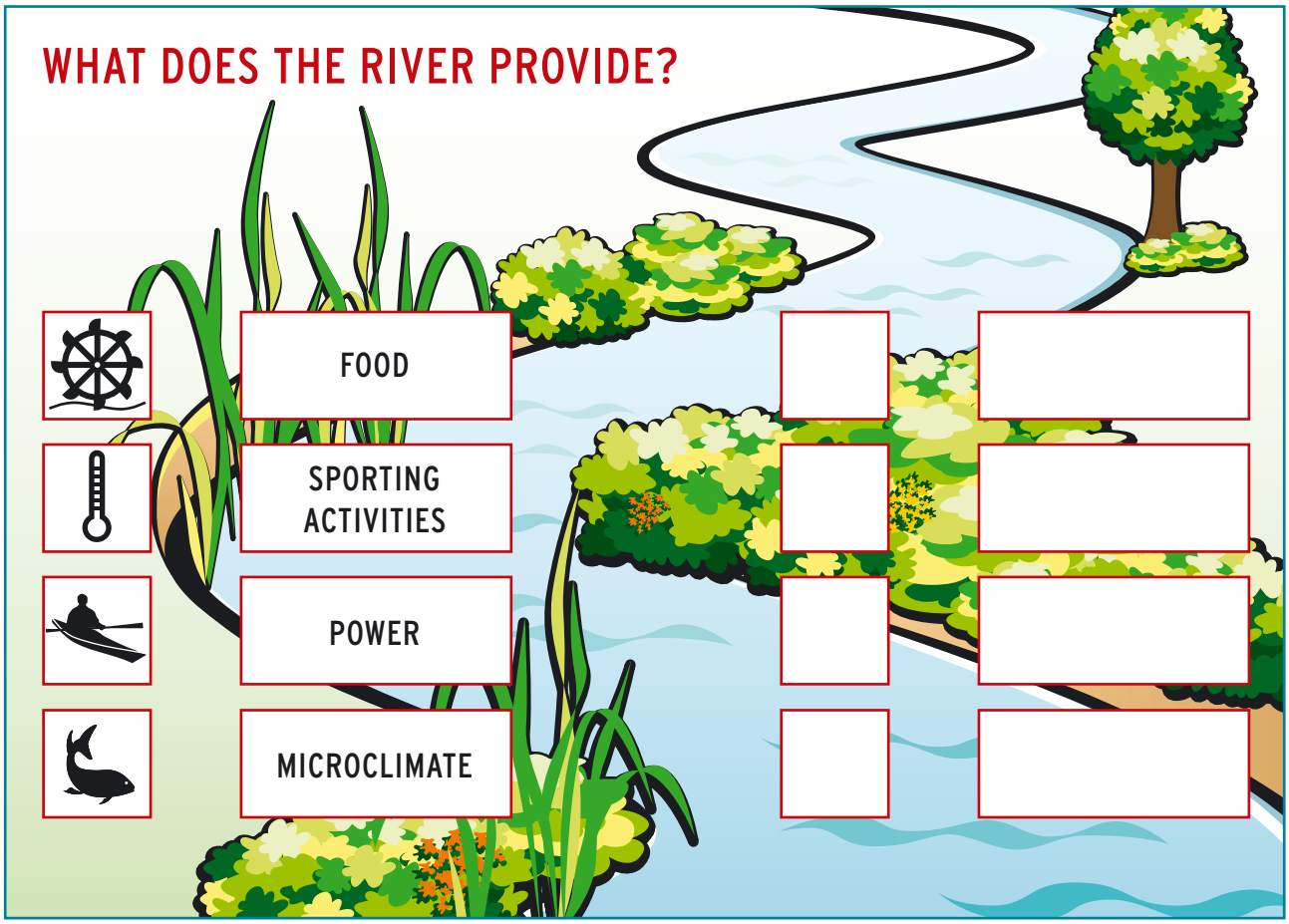
A RIVER IS MORE THAN JUST WATER

RIVERS AS A LIFELINE

A river is more than just water worksheet 1

Rivers – the lifeline of the human race. For thousands of years people all over the world have chosen to settle along the banks of rivers and streams, which gave them water for drinking and everyday life, provided protection and were often the only transport routes. The landscape along the river bank too helped people no end. The soil is often particularly fertile, producing rich harvests, and the climate is especially mild. Grape vines and fruit grow extremely well in river valleys. This allowed the settlements to grow into towns, laying the foundations for economic and cultural development throughout the entire region. Right up to the present day, rivers are extremely useful to us, but the sheer beauty and the natural world shaped by a river landscape have also fascinated and moved people across the centuries.

WHAT DOES THE RIVER PROVIDE?



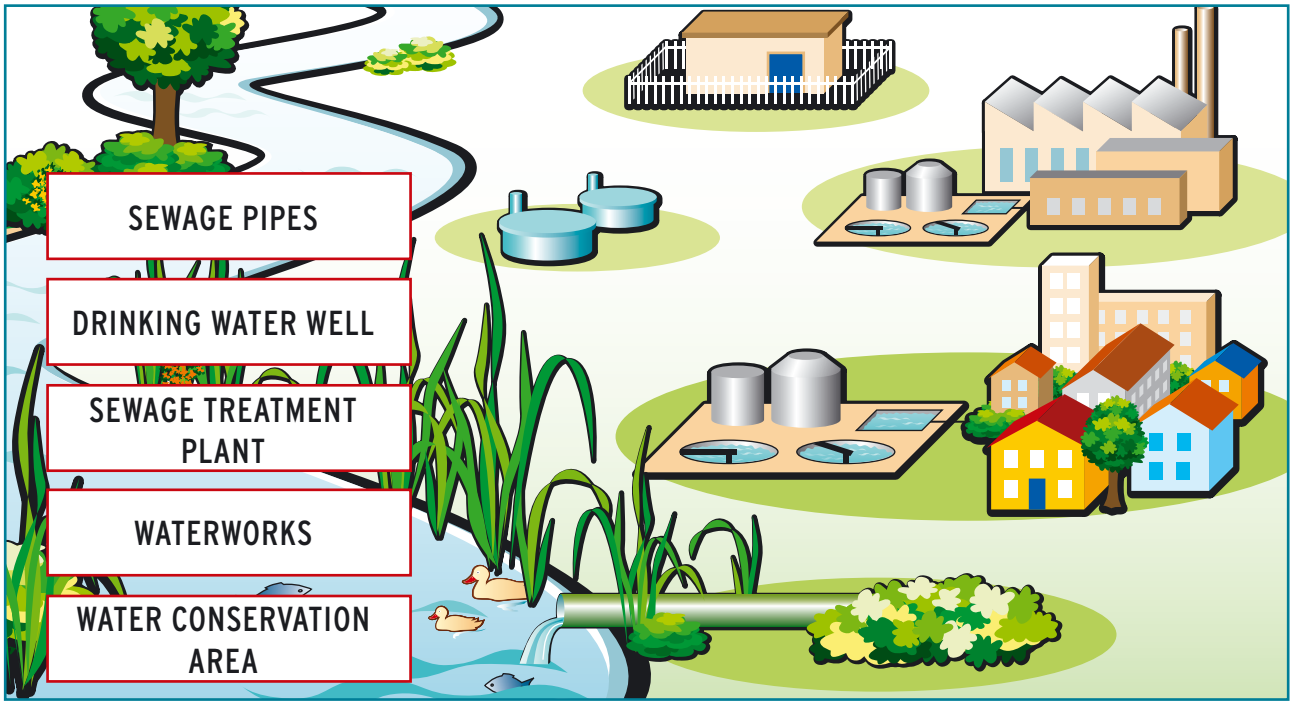
EXERCISES:

1. *Read the above text. Match up the terms listed with the appropriate image. Describe briefly the importance of each.*
2. *Think of more terms which categorise the benefits that rivers bring us. Draw a symbol for each in the empty boxes.*
3. *Rivers and streams are useful not only for people. What other living things benefit from the river, and how?*

IS THAT QUITE CLEAR?

A river is more than just water worksheet 2

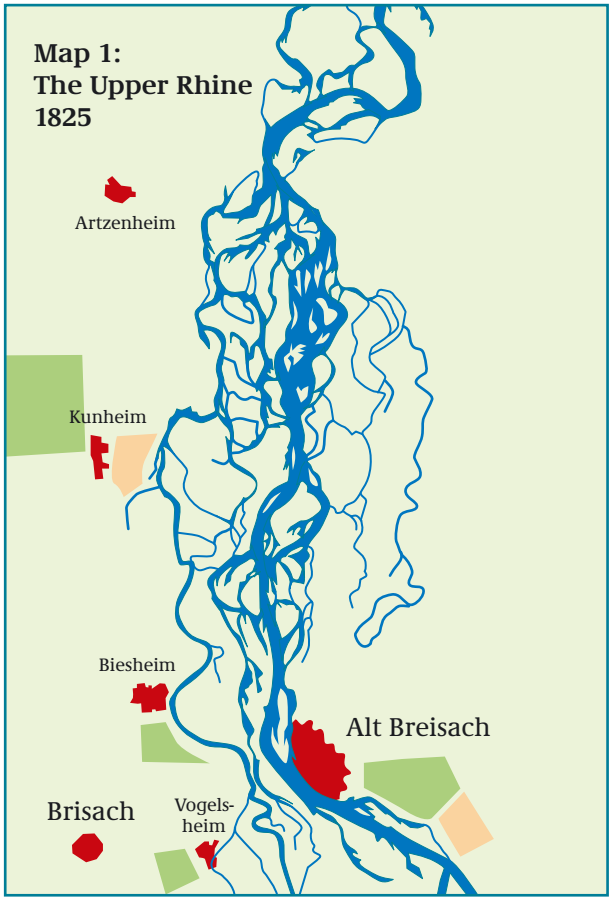
Just turn on the tap at any time of the day or night and out comes sparkling clear drinking water. We all take it for granted. But before the water gets to our taps, it goes through a great many complex technical processes. Most of the water we use as drinking water comes from groundwater wells, although some is also taken from springs, rivers and streams. This is why it is so important that groundwater and bodies of water are protected against harmful pollution. Once the water is collected, it is treated to ensure that the drinking water is pure and that it complies with the hygiene regulations. A vast network of pipelines carries the water to millions of households. Once it has been used by people to drink, and for washing and cooking, the once clean water becomes wastewater or sewage. It flows down into the depths of the sewage system accompanied by dirt and soap. It is complicated and costly to treat the wastewater produced by private households and by industry, because it has to be as clean as possible before it is fed back into the nearest river.

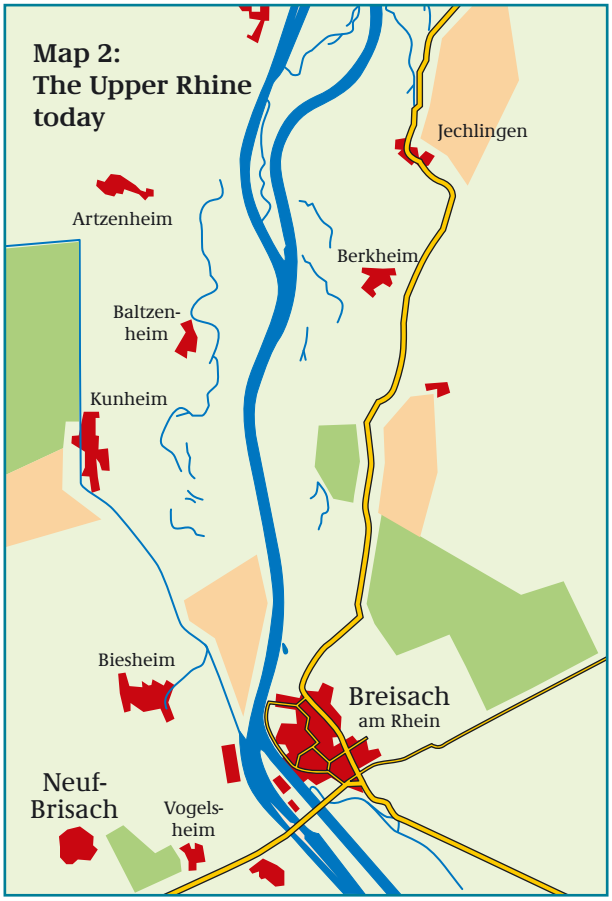


EXERCISES (GROUP WORK):

1. *Find out what each of the above terms means. You will find information in your biology and chemistry books, in dictionaries and encyclopaedias and on the internet (use a search engine). Present your findings to the class briefly. Think about how you can best explain to your classmates what the terms mean.*
2. *Match up the terms with the picture and draw arrows to indicate the route taken by water. Write in your exercise books exactly what happens at each place.*
3. *What are grey-water, drinking water, rain water, waste water, raw water? Put the terms in the correct order and enter them at the correct points on the picture above.*
4. *Why is drinking water valuable although we seem to have plenty of water and although drinking water can be produced easily? Why should we save drinking water? Give at least three reasons.*

The abandoned river courses and dead arms have been drained to allow us to build close to the river. The riverbed has been channelled, straightened and dredged for shipping. The River Rhine in Germany has had to cope with phenomenal anthropological interventions over the last 175 years. The results can be seen every time the river level rises. Massive flooding along the banks causes enormous damage.





Source: Federal Institute of Hydrology

EXERCISES (GROUP WORK):

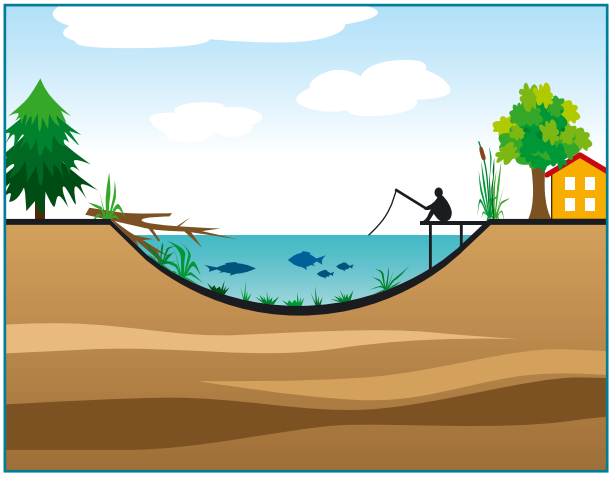
1. *You are a city planning team, planning a shopping centre for the area surrounding Breisach. Compare the two maps above and shade the area on map 2 where you think the shopping centre should not be built.*
2. *Imagine you have just moved into a house on the river bank with your family. Could your house be affected by flooding? Think about where you could obtain information about the risks of flooding.*
3. *Use the Internet to find out about different flood protection methods and present your findings to the class. Key words to consider: flood plain, renaturing, technical flood protection. Compare the pros and cons of the individual methods. Think about how best to present your results to the class. Your teacher will be able to make some suggestions as to where you can find the information.*

LIVING WITH THE RIVER

A river is more than just water worksheet 4

Rivers are generally developed in the interests of progress, to make them more easily navigable for instance, or to generate power. Embankments and dykes are intended to provide protection against flooding, and make it possible for people to settle close to the river. Initially at least this often has the desired effect. The full impacts of these interventions only become apparent in the medium term. Natural riverside meadows are destroyed – and with them we lose the habitat for many species of plants and animals. The many weirs prevent fish from swimming back upstream to spawn. Toxins pollute the water. When river development measures change the entire course of the water, things become dangerous for human beings too. A fast-running river can flood very rapidly. So new ways have to be found of living in harmony with the river.

Renaturing is understood to mean the restoration of habitats to a state as close as possible to that of the natural habitats that previously existed. When rivers and streams are renatured, an effort is made to restore the original, unstraightened riverbed, reducing the rate of flow and thus the risk of flooding, and to resettle the original flora and fauna in the area.



EXERCISE:

1. a) Look at the two illustrations above. Which illustration shows evidence of human intervention? Give reasons for your answer.

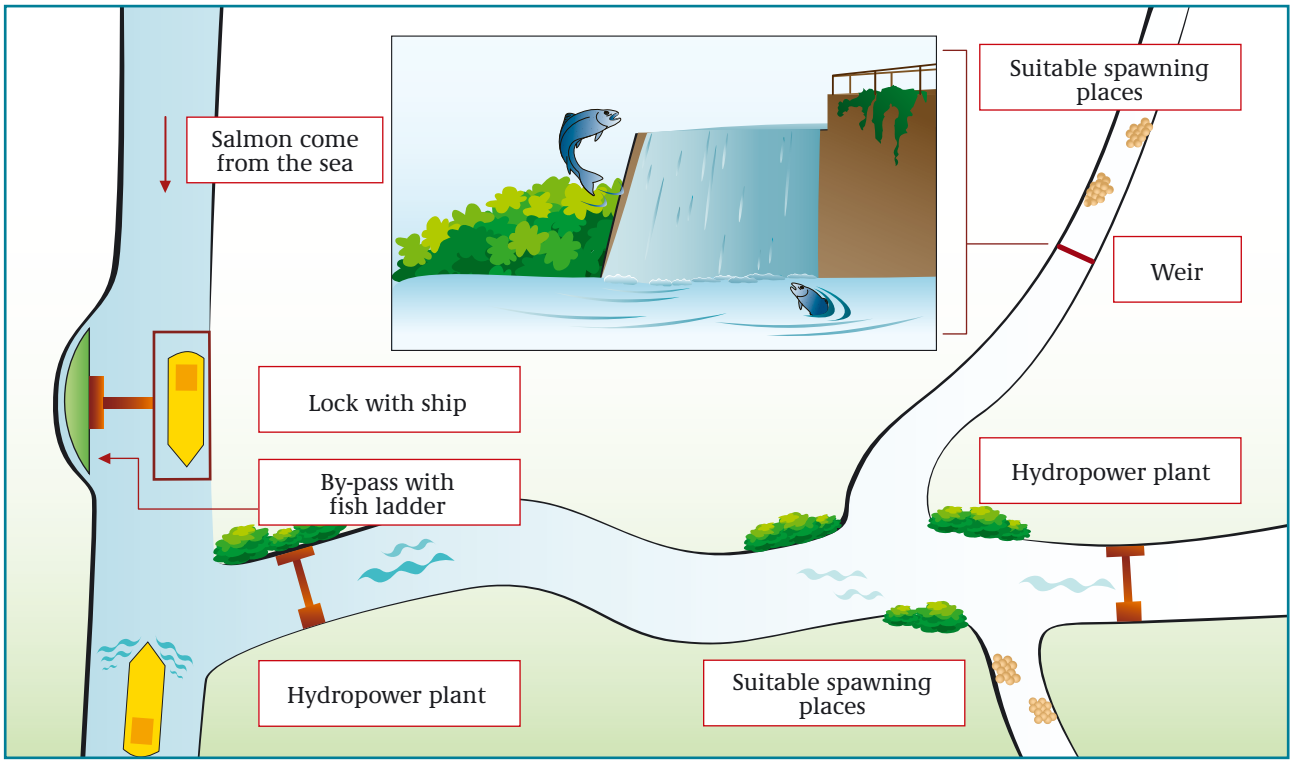
1. b) On which of the two rivers shown do more animals and plants live? Where will fish find better living conditions?

2. Imagine you are on the local council of your home town. The council is debating whether to renature the nearby river, or whether to develop it. Draw up a list of the main arguments, and analyse them. Here are some key words to help you: shipping, leisure/ recreation, flood protection, construc tion costs, maintenance costs, natural beauty, groundwater table, protecting flora and fauna, the river as an ecosystem. Can you think of other arguments?

NO ENTRY

A river is more than just water worksheet 5

One hundred years ago our rivers were still home to a huge number of fish species. The best known are salmon, trout and eel. And fish are not static: Salmon swim all the way from the sea upstream to their own hatching place to spawn. Eels, by contrast, swim downriver to the sea to return to their place of birth in the western Atlantic. Until only a few years ago it was the poor water quality that was responsible for the decline in our river fish stocks. But much has been achieved here, and today the water quality of most German rivers has improved significantly. We still have a huge problem though – weirs, locks and hydropower plants prevent fish returning to their spawning areas or to their winter quarters. There is, however, a way round the problem. Fish can learn to climb a ladder.



The obstacle course of the river (not to scale)

EXERCISE:

1. *Indicate on the illustration the points where obstacles block the way of fish seeking to return to their spawning places.*
2. *Consider the options available that would make it easier for fish to overcome these obstacles. You will find one possible solution in the diagram.*

For more information have a look on the Internet: http://en.wikipedia.org

THE EU WATER FRAMEWORK DIRECTIVE

A river is more than just water infosheet 1/3

Have you ever dreamt of swimming happily in the river and enjoying a freshly cooked river fish in a restaurant afterwards? This is hopefully a dream that will come true. In 2000, the European Union adopted a directive which is intended to make it possible:
The New EU Water Framework Directive

ALL-ROUND PROTECTION

The new directive means that water protection will be accorded even greater priority inside Europe, and that all waters are to be protected, from the groundwater that is so important as a source of drinking water to standing water such as ponds and lakes, and from running water like streams and rivers to coastal waters. The directive clearly stipulates that river basins as a whole are to be protected. In other words, rivers are seen as a single unit, from the source to the estuary, and this unit embraces not only the river per se and the water flowing in it, but also the entire area surrounding the river, the so-called river basin. The overall objective of this directive is to make bodies of water as natural as possible again, with a wide variety of plants and animals, with their original unaltered form and flow and with the natural quality and purity of the water. If bodies of water and their ecosystems are healthy, they are to be preserved in this state, and where this is not the case, they are to be upgraded.

WHERE DO WE GO FROM HERE?

The EU Framework Directive contains an important and fundamental principle: no body of water is to be degraded; all are to be upgraded. Developments are to be measured in terms of those bodies of water that are already considered exemplary (reference rivers/lakes, etc.). By 2004 the necessary data on the status of our rivers, lakes etc. was to be recorded and passed on to the European Commission. In the next five years, plans are to be developed for the renaturing of our waters. These plans must then be put into practice by 2012. By 2015, EU member states must present evidence that the objectives have been achieved. Any failure to achieve the objectives is likely to be expensive, as the EU can impose fines. One special feature of the Water Framework Directive is that it takes its lead not from political borders, but from natural geographical borders, i.e. the river basins, and not only in the EU but throughout Europe. The largest river basin in Europe is the Volga basin; the second largest the Danube basin. All riparian states (i.e. states bordering on the river) are to be involved. This is comparatively easy for the Rhine (ranked 11th), the Elbe (ranked 12th) and the Oder in particular (ranked 13th), because relatively few countries are involved. Another special feature of the Directive is its insistence that the local populations should become involved to a greater extent in water protection. Planning for the necessary measures must be published, to give citizens a chance to have their say.

SEVERAL FACTORS ARE TAKEN TO GAUGE THE STATE OF A RIVER

1. Structural variety

The natural flow of streams and rivers varies. Slowly meandering sections alternate with swiftly flowing sections. They do not naturally look like water roads. Rivers meander in loops, banks are not built up but are covered with natural vegetation, the riverbed is not reinforced or dredged. There are shallow sections with sandbanks and little current, and others where the water is deeper and the current stronger.

2. Passability

A natural stream or river is passable for all living creatures which live in or on it. There are no unnatural obstacles like locks or weirs, which would for instance prevent migrating fish like salmon returning to their place of birth to spawn. When anthropogenic (man-made) obstacles block the waterway, a fish ladder should be built to enable fish to circumvent the obstacle.

3. Intact flood plains

Streams and rivers are not limited to the actual course of the stream or river. When the snow melts in spring or after extremely heavy rainfall, rivers and streams often burst their banks and flood the surrounding area. This flood zone is known as the flood plain of the river. It consists of damp or wet low-lying areas along the course of a stream or river, and provides a habitat for a large number of rare plants and animals. Good examples include storks and the frogs and other amphibians that make up the storks' diet. Other examples include such rare plants as orchids. Typical flood plain trees are alders which stand fairly close to the water (softwood flood plains), while ash, elm and maple grow slightly further away from the river (hardwood flood plains). Natural flood plains have become very rare in Germany. Most have been drained and used for agriculture or human settlements.

4. Water quality

Until about twenty-five years ago, the water quality in German streams and rivers was worryingly poor. Pictures of frothy foam on the Rhine and reports of masses of dead fish floating in rivers caused many people major concern. Why did these things happen? Wastewater from industry and private households was discharged into rivers, worsening the chemical and biological quality of the water to a point where it could support practically no life. The construction of sewage plants has significantly improved the situation, and today the water quality of most rivers and streams is good. There is, however, still a long way to go before we can once again go fishing on the banks of the river, or enjoy a swim.

5. Renaturing

Renaturing is understood to mean the restoration of habitats to as natural a state as possible. In this case we are talking about habitats along or in running water. The first step in renaturing is the removal of bank reinforcement. The river bed is widened and the banks flattened. The river can once again take its natural winding course. Site-appropriate trees are planted along the banks. If the renatured river is left to its own devices, a large number of animal and plant species resettle on their own (succession). A straightened, culverted, engineered stream can once again become a living river, meandering through the countryside, with lateral branches, old branches and abandoned river courses, and a habitat similar to that which would have originally existed.

6. Biological water quality

The quality of running water is determined not only in terms of the water structure and water quality, but also in terms of the flora and fauna it supports. The organisms that live in the water make certain demands of their environment. The life that a body of water supports is thus a reflection of the state of the water, and provides us with valuable information about living conditions over a longer period. Biodiversity in a body of water presupposes a variety of habitats within a multi-structured body of water and that the water is as unpolluted as possible. In addition to water contamination caused by the discharge of substances into rivers and streams, or substances being washed into them from adjacent farmland or allotments, river engineering and land consolidation measures have led to a further deterioration of the living conditions of the animals and plants that live there. Running water as an ecosystem comprises the biocenosis (the living contents) and the biotope (the pertinent habitat). The environmental conditions change along the course of a river, the further it flows from its source. Generally, the water temperature rises, as does the nutrient content of the water, while the rate of flow will generally drop. As a result, the species that live in and along the stream or river also change.

7. Features of a river restored to its natural state

The course of the river is not straight, and can shift. Steep and shallow banks alternate, and the depth and breadth of the river vary. Natural obstacles occur, along with gravel and sandbanks, stones and plant roots. The banks are lined with trees, shrubs, reeds and water plants. There is a rich variety of plants and animals (fish, frogs, insects and their larvae).

8. Advantages of naturally running water

These successfully renatured streams and rivers are extremely effective in biological terms. They provide a habitat and a migration route for many animals and plants, they are self-cleansing to a large degree, have a beneficial balancing effect on the climate (providing a channel of fresh air, evaporation). They grace the landscape and are low-maintenance projects.

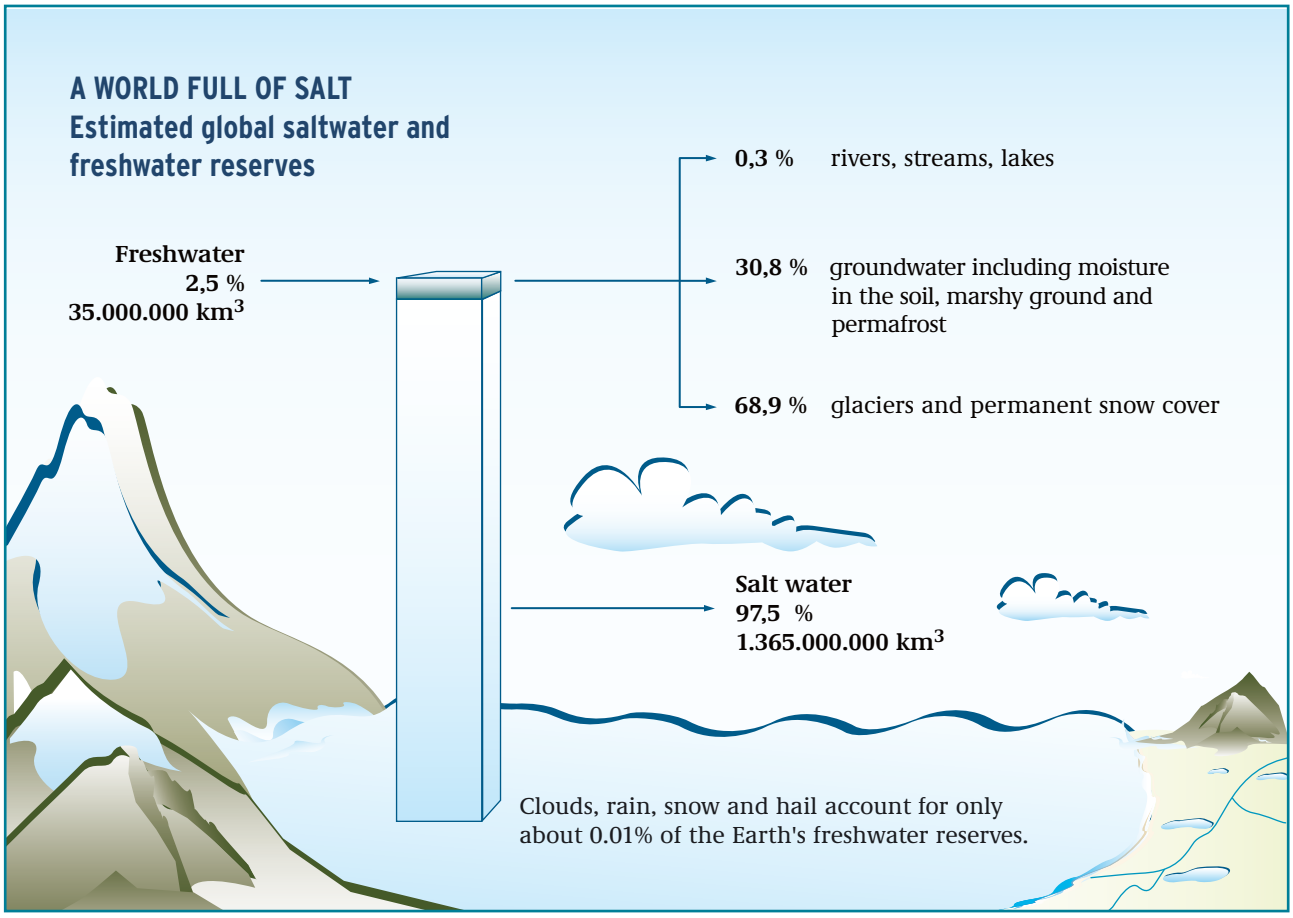
LIFESTYLE AND WATER

THE WATER OF THE EARTH

Lifestyle and Water worksheet 1

Water covers two-thirds of the surface of the Earth. That is why the Earth is sometimes referred to as the blue planet. More than 97 percent of all water on Earth, however, is salt water. Freshwater accounts for only 2.5 percent, most of which (about two-thirds) is unavailable to us because it is locked in the polar ice caps and in glaciers. Another third of freshwater reserves are underground reserves, and only a tiny 0.3 percent of all freshwater reserves on Earth take the form of surface water, such as rivers, streams and lakes.

Fig. 1: Water on Earth



Source: UNESCO (1999)

EXERCISES:

1. Use the text and the diagram to help you explain what freshwater is.

2. What percentage of the Earth's freshwater reserves can be found in surface water? Tick the correct answer.

☐ *3,0 percent* ☐ *30 percent* ☐ *0,3 percent*

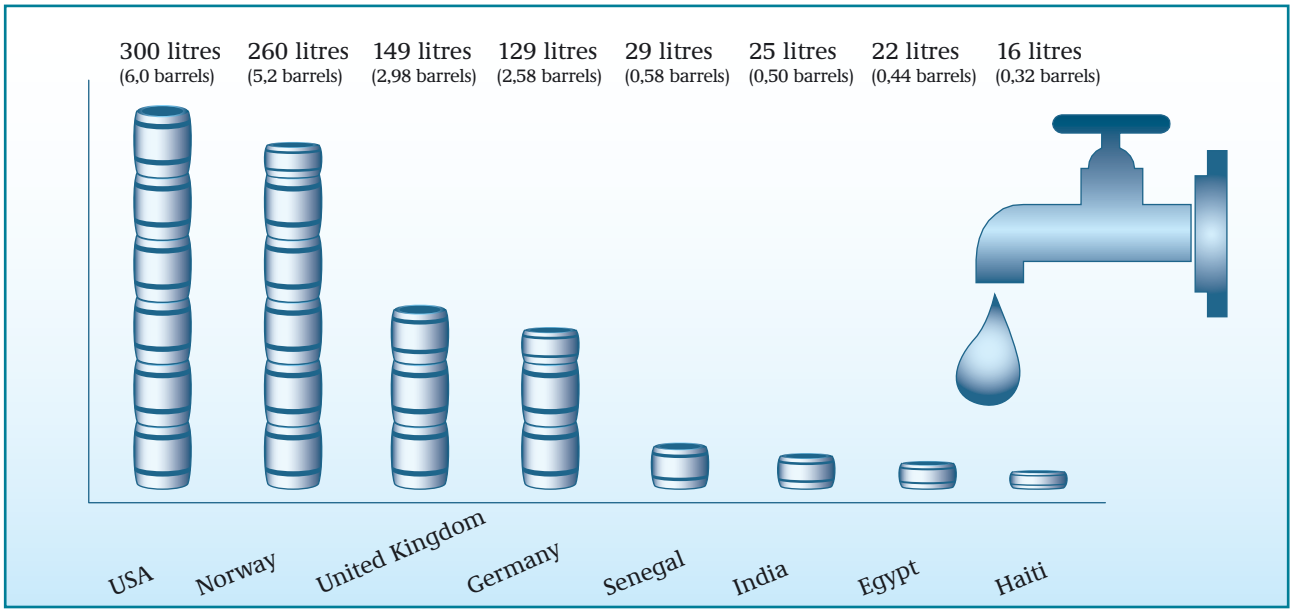
3. What types of freshwater reserves do you know? What do you know about them?

4. Which of these freshwater reserves are used to produce drinking water?

HOW MUCH WATER DO WE REALLY NEED?

Over the past 100 years, global water consumption has expanded by a factor of almost ten, according to United Nations statistics, although the population of our world has only quadrupled over that period (expanding from 1.5 to 6.5 billion). Water consumption has thus risen much faster than the world's population. The problem is, however, that the water reserves of our planet are not expanding, and that access to safe water is very inequitably distributed. Many people in developing countries have to drink, cook and wash with the same amount of water every day that we use to flush the toilet once.

Fig. 2: Who uses what? Daily average drinking water consumption per capita in selected countries (approximate values!)



Sources: UNEP (2002) et al.

What is drinking water?
All the water that we use for drinking, cooking, preparing food and drinks, personal grooming, and cleaning objects that come into contact with food is drinking water. The properties of drinking water are such that if you drink between two and three litres a day all your life your health will not suffer in any way. This is laid down in Germany, for instance, in the provisions of the Ordinance on Drinking Water.

EXERCISES:

1. *Along with a partner, think about why the amount of water consumed in individual countries varies so widely. Take into account the climate and rainfall, the economic situation of the country and different ways of life. You can find more information in the thematic maps in your school atlas, in encyclopaedias and on the Internet (see list of links).*
2. *Find out where drinking water comes from. Use your biology and geography books or the Internet. Produce a short paper with a partner that you can present to the class. Put the information together in the form of an overview with a drawing.*

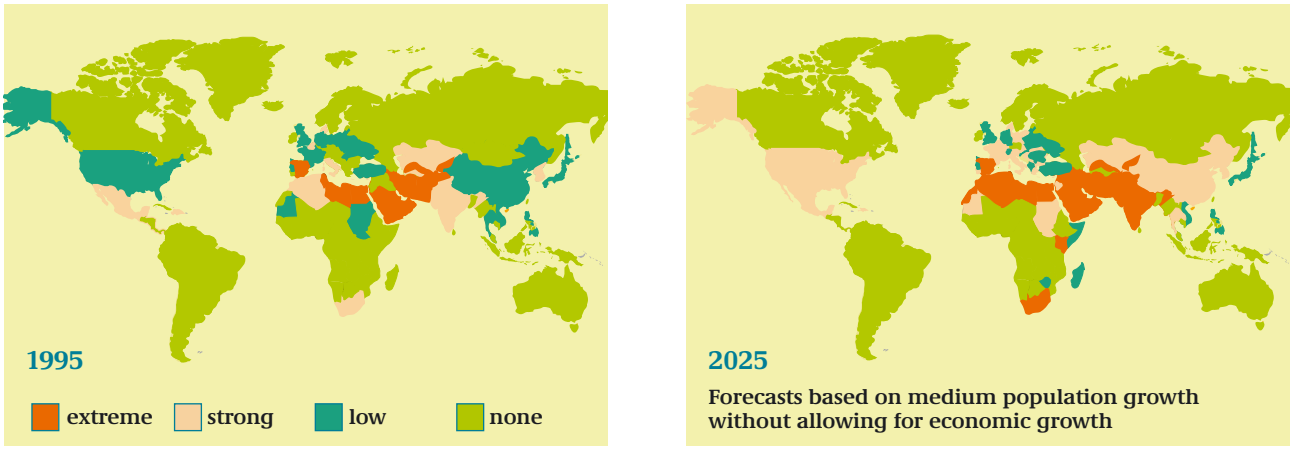
IS THERE ENOUGH WATER FOR EVERYONE?

Lifestyle and Water worksheet 3

More than six billion people share the freshwater available on our planet, but this precious liquid is very unevenly distributed. Some regions have lots of available water, say in North and Western Europe and in South America. In other regions, however, in the arid and semi-arid regions of North Africa and the Middle East, things look quite different. There is not enough rain to refill the rivers and replenish the groundwater reserves, especially when demand for water just keeps growing as a result of rising population numbers and economic development. Pollution and the high level of water consumption by industry and agriculture are other reasons why drinking water is becoming scarce in some parts of the world. Today more than one billion people have no access to safe drinking water. Many countries of the world already suffer a constant water shortage (see Figure 3).

The term "water resources management" is used to describe the way we deal with water, whether we use it sensibly and manage it responsibly, or not. If we don't, we are partly to blame for water shortages. That means that there is enough water, but the water is of such a poor quality that it cannot be used as drinking water, or too much water is used in one place which is then not available elsewhere. This happens for instance if crops that are basically unsuited to the local climate are planted and require a huge amount of water for irrigation. That water then cannot be used for other things. Often ineffective and/or leaky irrigation plants mean that huge quantities of valuable water are lost. This is another example of poor water resources management. But it is not only agriculture that is responsible for water losses. The problem is also aggravated by a lack of pipes or leaky pipes. In some countries up to forty percent of drinking water is lost in this way before it even reaches the consumer.

Fig. 3: Drinking water shortages worldwide



Source: UNEP (2003)

EXERCISES:

1. *Compare the 1995 map with the forecast for 2025. Look for the countries in which water shortages seem set to worsen. Draw up a table of these countries.*
2. *Give at least four major reasons why it will become difficult to provide the entire population of these countries with supplies of safe drinking water. Use both the above texts to help you.*
3. *Examine how climate change could affect the available drinking water reserves, especially in Southern Europe and North Africa. You will find the information you need on the Internet.*

IN THE BEGINNING THERE WAS THE VILLAGE ...

In 1800 only about two percent of the population of the Earth lived in towns and cities. By the year 2000, about 50 percent of us lived in urban areas. By 2030 as many as two-thirds of the world's people (75 percent) could be city dwellers. This trend is particularly clear in developing countries. Over the last forty years we have seen small towns mushroom into what we today call "megacities". These are major cities with 10 million or more inhabitants (e.g. Mexico City). This meteoric growth goes hand in hand with a huge spread in slums. Slums spread without any planning, which makes for enormous problems in terms of ensuring basic supplies for the inhabitants. As a result many city dwellers have no access to safe drinking water and/or proper sewage systems (Figures 4 and 5). Safe water is often brought in from far away by tanker and sold at high prices. Sewage is discharged untreated into streams, rivers or canals. This frequently results in appalling hygienic conditions. Germs in polluted and standing water cause dangerous diarrhoeal diseases such as dysentery, typhus and cholera.

Fig. 4: Mains water connections (in larger towns)

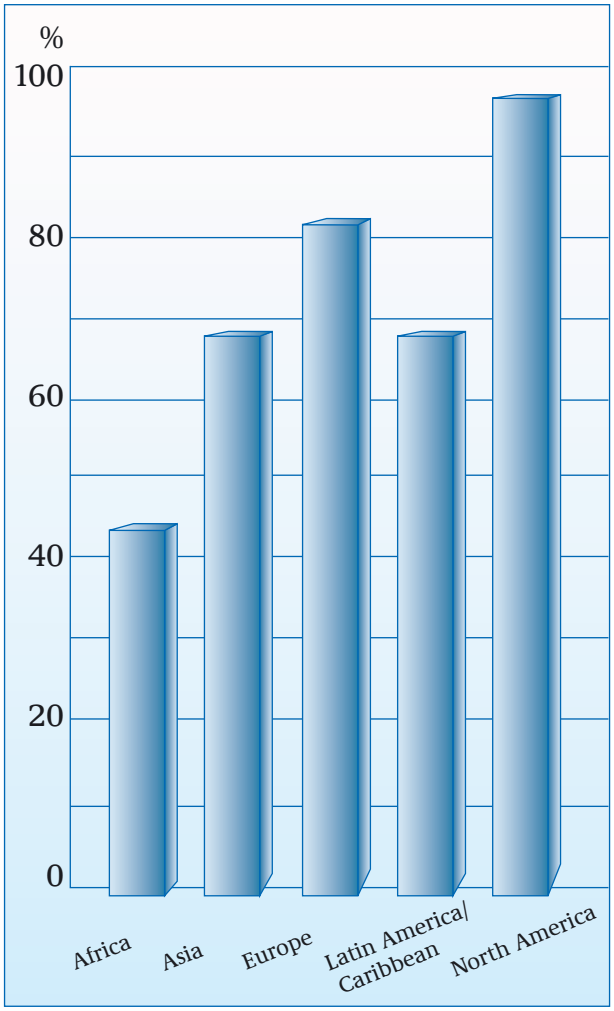
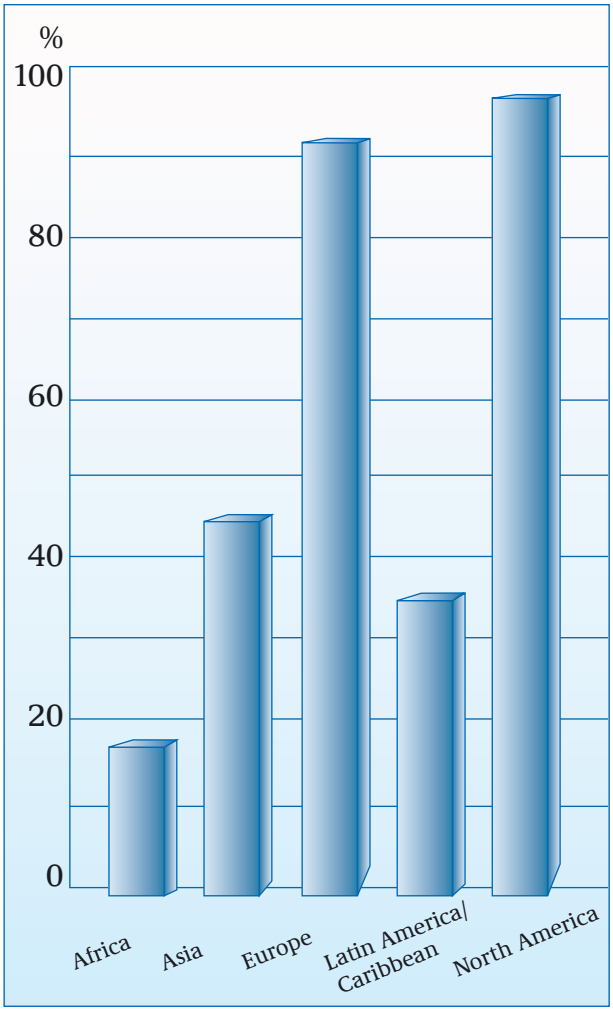


Fig. 5: Percentage of households with sewage connections (in larger towns)



Source: World Water Development Report (WWDR, 2003)

IN THE BEGINNING THERE WAS THE VILLAGE ...

Every year millions of children die as a result of diarrhoea and other diseases caused by unsafe water. Poor quality drinking water, a lack of hygiene and/or the lack of sanitation are responsible. In many developing countries people depend on open water holes, which are often polluted or contaminated and at certain times of year are inaccessible. The little safe water available is so valuable that it is only really used for drinking and preparing food. Often there is not even enough water for people to wash regularly. In many countries too there is a lack of suitable sanitation, which would prevent human excrement and domestic waste water ending up in open bodies of water or in the groundwater.

EXERCISES:

1. Use the text to help you explain the term "basic sanitation".

2. Look at the two graphs and assess the following statements. You can assume that the households with sewage connections in Figure 5 are also connected up to a mains water supply (Figure 4).

a) The sanitation situation in larger towns is worst in Africa.

☐ *true* ☐ *false*

b) More than fifty percent of households in larger towns are connected to mains water supplies on all continents.

☐ *true* ☐ *false*

c) In Asia's larger towns only half of all households with a mains water connecti on also have a sewage connection.

☐ *true* ☐ *false*

d) In Europe and North America all households in larger towns have a mains water connection and a sewage connection.

☐ *true* ☐ *false*

On a worldwide scale, agriculture is the largest consumer of water. On average, about two-thirds of all water withdrawn is used in the agricultural sector, around the globe. In Europe and North America about two-thirds of water withdrawn is used in industry and by private households, with agriculture accounting for the remaining third. In Asia, Africa and Latin America, by contrast, more than 80 percent of water withdrawn is used for agriculture.

Why does agriculture need so much water? Partly because some plants that are vitally important for us, such as maize, rice and wheat, need a lot of water, meaning that crops have to be irrigated in countries where it does not rain enough. To produce one kilogramme of cotton, for instance, 20,000 litres of water are needed. Many tropical and sub-tropical countries export agricultural produce. As they do so they export huge quantities of ”virtual water“. For countries with few available water resources this is already a problem, and in others it is set to become a problem in future.

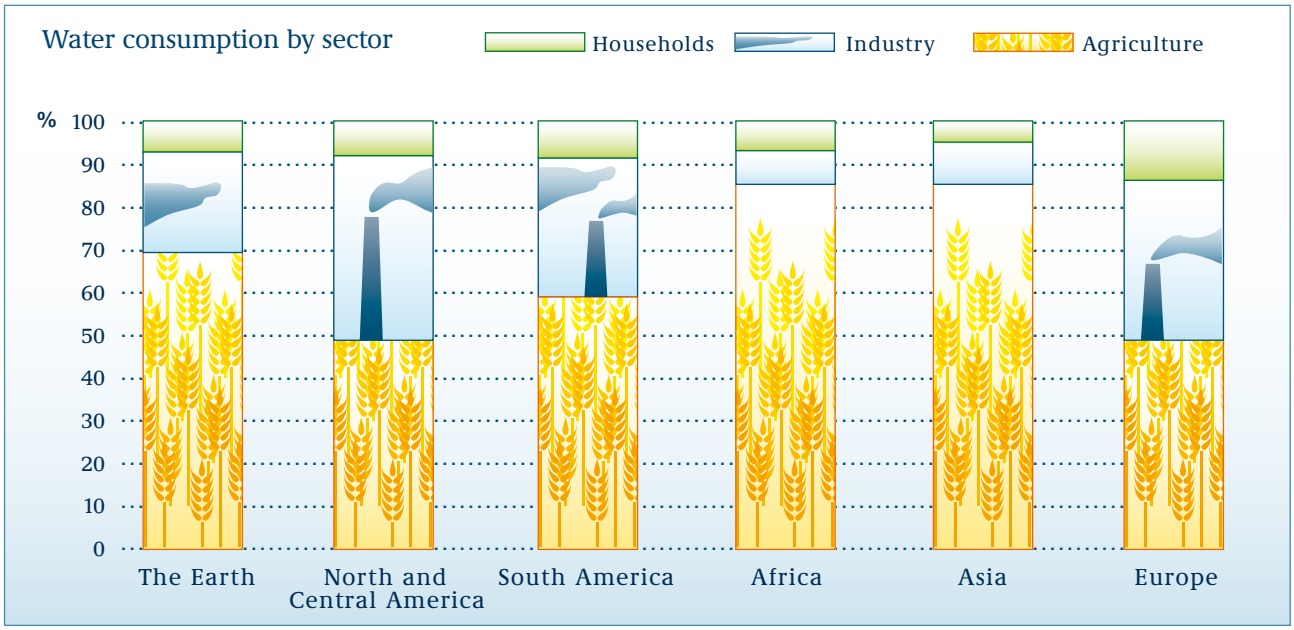
What is ”virtual water“?

The term ”virtual water“ was coined at the beginning of the 1990s. It refers to the ”water contained in products“. The water needed for the entire production process of an agricultural or industrial product is known as the virtual water contained in that product. Virtual water is an important way of calculating the real water consumption of a country. The water consumption is the sum of domestic consumption and imports of virtual water (water contained in imported products) minus exports of virtual water (water contained in exports).

Source: http://ihp.bafg.de/servlet/is/8213 > English > Information Service

World trade can have positive sides too for countries with few water resources. If a country like Egypt, for instance, imports cereals, which contain about 2,000 litres of virtual water per kilogramme, and exports citrus fruits which contain two-thirds less virtual water, this indirectly helps save water.

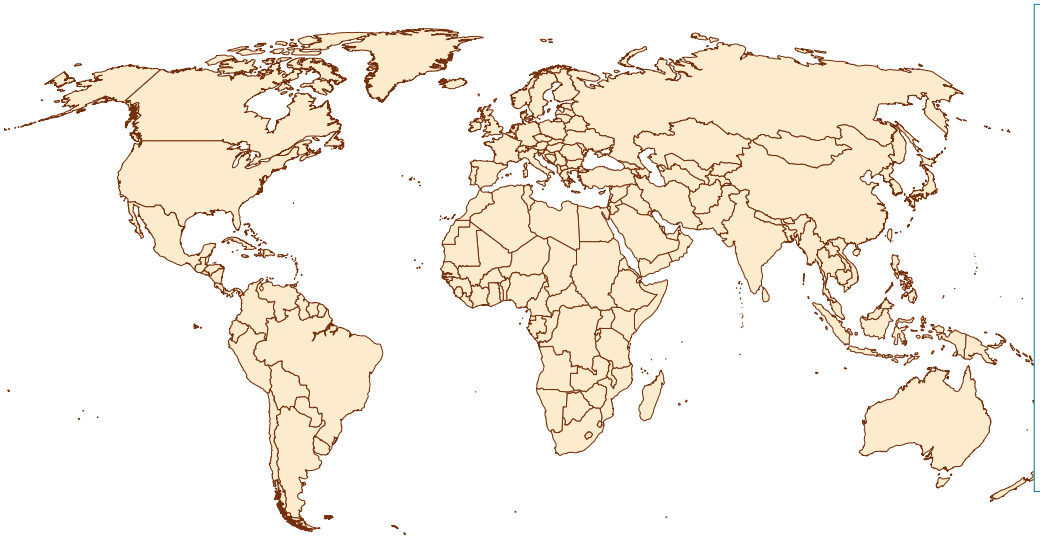
Fig. 6: Water consumption by households, industry and agriculture worldwide



Source: Deutsche Welthungerhilfe (German Agro Action)

VIRTUAL WATER

Lifestyle and Water worksheet 6



Virtual water in food
(figures given per 1 kg,
approximate values)

A) Orange juice:	25 l
B) Rice:	3.000 l
C) Lemons:	1.000 l
D) Tea (non-herbal):	10.000 l
E) Soya:	2.000 l
F) Bananas:	1.000 l
G) Cocoa:	10.000 l
H) Coffee:	20.000 l
I) Tropical fruit (mangos etc.)	1.000 l

Agricultural produce from developing countries (Table 1)

Product	Country of Origin	Virtual Water Consumption (litres)

EXERCISES:

1. *Many tropical and sub-tropical countries export food and other agricultural produce, such as tropical fruit, tea and coffee to us in Europe. Look in your school atlas and check up on the Internet, in your local supermarket, at the greengrocer and your local market to see which countries export the products above. Fill in the relevant letters for each product or products on the world map.*
2. *Enter in Table 1 all the agricultural produce you have found. Then add in the appropriate column the country of origin and the virtual water consumption. Do you think that some of these countries face problems with water supply? Look again at Figure 3 on Worksheet 3 to help you.*

VIRTUAL WATER – WHAT DO I CONSUME?

Virtual water consumption per month (Table 2)

Product	Quantity per month	Quantity of virtual water
Rice	150 g	450 litres
Bananas		
Coffee		
Non-herbal tea		
Orange juice		
Meat (750 g soy beans per kg meat)		
Lemons		
Cocoa		
Kakao		
Tropical fruit (mangos, etc.)		
Total quantity of virtual water		..... litres

EXERCISES:

1. *The class should agree on ten basic foodstuffs. Keep a record of how much you eat of each type of food in one week. Take an average of 30 percent cocoa for chocolate. For meat, count 750 g ground soy beans per kilogram of meat (pork, beef, poultry) because ground soy accounts for a major part of animal feed). Multiply your results by four to give you quantities for a month and enter the results in Table 2.*
2. *Take the figures from the table to estimate how much virtual water was used to produce this food. Multiply your results by twelve to work out how much virtual water was used in a year to produce your food.*
3. *Count up how many cotton T-shirts and jeans you possess. Weigh one pair of jeans and one T-shirt, and use these figures to calculate the total weight of your jeans and T-shirts. Now work out how much virtual water was used to make your clothes. You will be amazed!*
4. *Get into groups and discuss how you could reduce your virtual water consumption. List all your ideas and explain which ideas are good and why, and which you do not find so good. Think about the pros and cons of putting your ideas into practice. Think how to present these ideas convincingly to the class.*

THE GLOBAL WATER SITUATION

Lifestyle and Water infosheet 1

1. Over-exploitation of water resources

Currently, according to the United Nations, more than 430 million people around the globe are facing water shortages. Rapid population growth, urbanisation, accelerating industrial development and the expansion of irrigated agriculture are putting increasing pressure on water resources in many parts of the world. Agriculture alone uses up to 80 percent of available freshwater worldwide. If the irrigation methods used are then ineffective, the impacts on soil and groundwater reserves can be extremely serious. The over-exploitation of water resources (lakes, rivers, groundwater) leads to a lowering of the groundwater table and, in coastal areas, to rising salt water intrusion. This is particularly critical, because most of our drinking water comes from groundwater reserves. By 2025 the United Nations expect a total of 64 countries to be suffering serious water shortages, 31 in Africa, 19 in Asia and 14 in Latin America.

2. Worsening water pollution

At the same time, 90 to 95 percent of industrial and domestic wastewater is discharged untreated into lakes or rivers. Fertilisers and pesticides from farmland are also washed into rivers and lakes, worsening contamination. Since the 1960s, the pollution of water resources caused by inorganic substances has more than doubled. This is making it more and more expensive to purify the water resources in some regions. Pollution also accelerates the degradation of ecosystems (with loss of biodiversity, and the drying out of wetlands, etc.), and the loss of ecological viability.

3. Inadequate access to water supplies and sanitation

The inadequate access of the population to safe drinking water and to appropriate sanitary facilities is one of the major problems in the water sector. Although the overall situation has improved markedly, especially in the last fifteen years, more than 1.1 billion people are still forced to survive without safe drinking water and more than 2.6 billion have no access to sanitary facilities that are acceptable from the health and ecological viewpoints. The consequences for these people are not only that they (generally the women) have to spend a huge amount of time and energy fetching water and ensuring hygiene in the home, but also the spread of water-borne diseases which cost more than 3 million lives a year. The World Health Organisation (WHO) estimates that 80 percent of all diseases in developing countries are caused by inadequate water supplies and sanitation.

4. Water and climate change

Climate change too is having an impact on water resources management. Climate models predict that rising temperatures will result in strong regional increases or decreases in rainfall, which will have direct consequences for the water resources available. Scientists expect more frequent extreme droughts and flooding, which can result in major economic losses as well as social and ecological disasters.

VIRTUAL WATER

Lifestyle and Water infosheet 2

Virtual water is the term used to designate the quantity of water contained in a product or used to make that product. Along the same lines as the ecological rucksack[1], the concept of virtual water embraces the total quantities of water used all the way along the line to manufacture a product.

Almost every product contains virtual water. For the production of a 32 MB computer chip weighing only two grams, for instance, about 32 litres of virtual water are needed, while manufacturing a car can use up to 400,000 litres of water. Most water is consumed in agriculture, which accounts for up to 80 percent of freshwater used.

About 2,000 litres of virtual water are needed to produce one kilogramme of a cereal crop, depending on the climate of the area where it is grown. The production of one kilo of cheese absorbs between 5,000 and 5,500 litres of water, and up to 16,000 litres of water may be necessary to produce only one kilogram of beef. The water consumption of nations therefore has to take into account the virtual water balance; and individual water consumption cannot only be defined in terms of the water used to drink, shower and wash the car. An average US citizen, for instance, uses about 2,000 litres of virtual water every day in beef consumption alone.

The export of goods with a high virtual water content is a potential source of conflict in regions already suffering water shortages. This applies, for instance, to cut flower production in Kenya. In 2001 Kenya produced some 52 million tonnes of flowers for the European, Japanese and North American markets, while 3 million Kenyans suffered water shortages. The European Union alone imported flowers from Kenya worth a total of 153 million euros in the year 2000. Most of these flowers are irrigated with water taken from Lake Naivasha, which is economically and ecologically important. The lake and its surrounding area are home to 350 bird species, hippopotamuses, buffalo, apes and other rare animals, and the water is used by the Massai, a tribe of nomadic herders, for their animals. Their existence is under threat, not only because water is becoming increasingly scarce, but also through contamination caused by fertiliser and pesticides. Without knowing it, flower lovers in distant countries are thus gnawing away at the livelihood of sections of the local population, which do not benefit from the revenue generated by the sale of flowers.

The withdrawal of water in the form of virtual water can entail existential problems for the local people, not only on the fringes of the world market or in developing countries. It can be just as much of a threat to people in industrialised countries, in the backyards of the global consumers. One particularly shocking example is provided by the Black Mesa Kayente coal mine in the south-west of the USA. At the mine, the Peabody Western Coal Company, the world's largest privately owned coal producer, breaks down the coal after mining, mixes it with (drinking) water, and pumps it through huge pipelines to Nevada, where it is processed and transported onward. Every day the pipeline transports about 43,000 tonnes of coal sludge. To produce this, Peabody uses about 480,000 litres of water an hour. The annual water consumption is of the order of 5 billion litres. The water is taken from the Navajo aquifer, which is the only aquifer in the area to provide water of such a good quality that it can be used as drinking water. It also feeds most of the rivers having their source in the Black Mesa. In this largely arid region, the water from these sources is the fulcrum of the social, spiritual and cultural life of the Hopi people who call the area their home. They make use of the biodiversity of the wetlands for their ceremonies, and honour a species of water snake found in the sources. Around the larger sources they till a few fields, and use the sources for drinking water. The sources are, however, increasingly drying up, which is threatening the social lives and the agricultural activities of the Hopi. As far back as 1995, studies showed that Peabody and its coal production was responsible for about two-thirds of the drop in the groundwater table. By 2011 a large number of the sources used by the Hopi are expected to dry up altogether.

Source: Fair Future. Wuppertal Institute for Climate, Environment and Energy. Munich, 2005

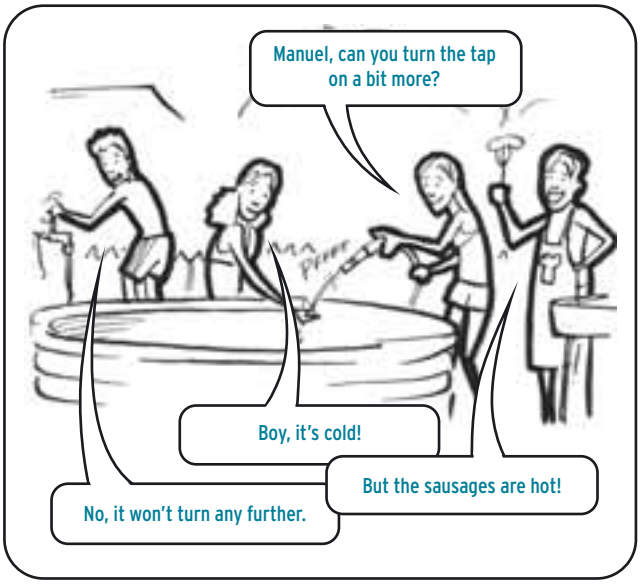
[1] The material input of a product (service) minus the weight of the product itself. The material input is defined as the life cycle wide total quantity (in kg) of natural material moved (physically displaced) by humans in order to generate a good. (Definition by the European Environment Agency)

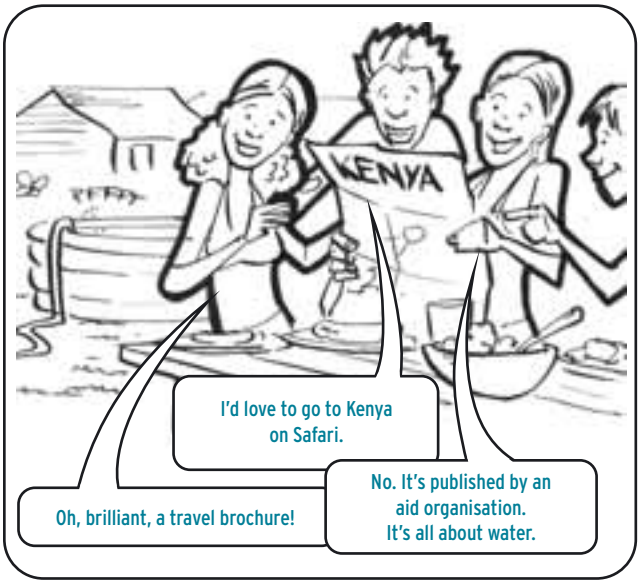
HIGH AND DRY

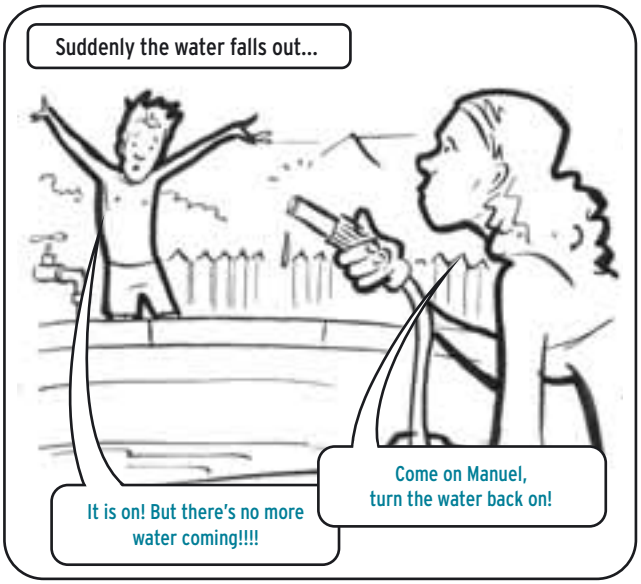
HIGH AND DRY

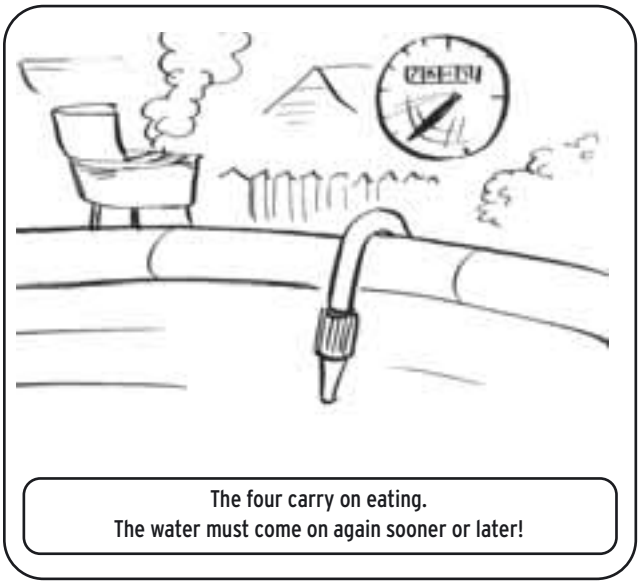
Framework Story for Water – Storyboard page 1/6

At Manuel's parents' allotment.



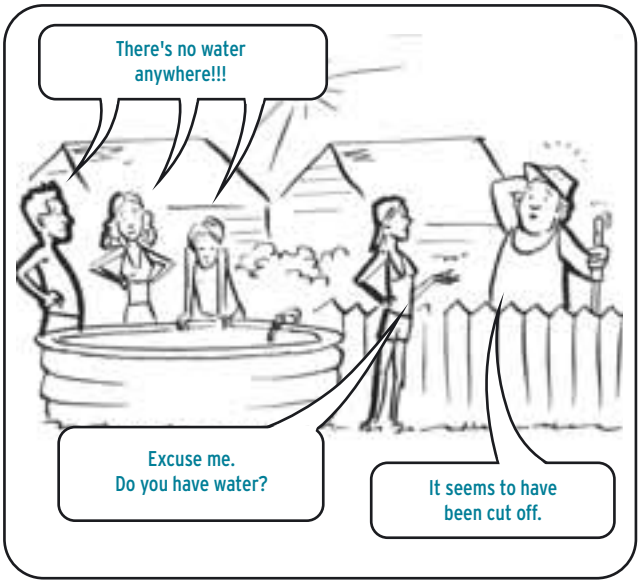


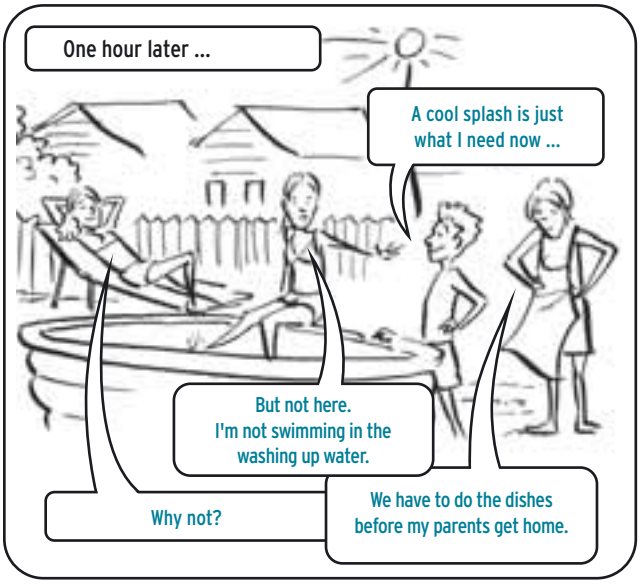


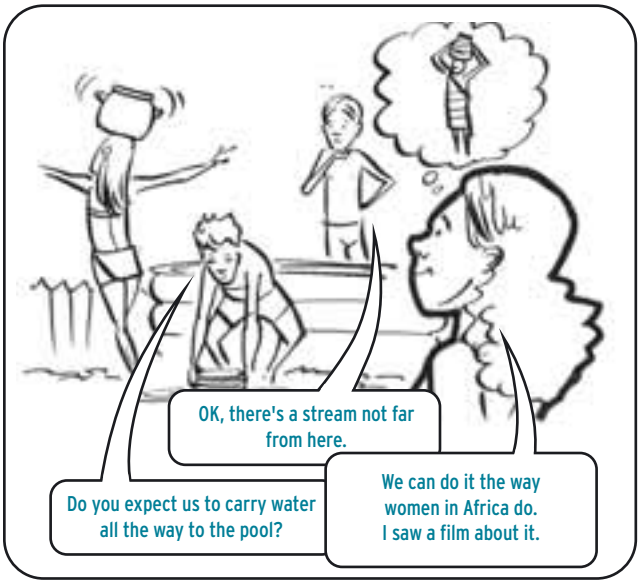


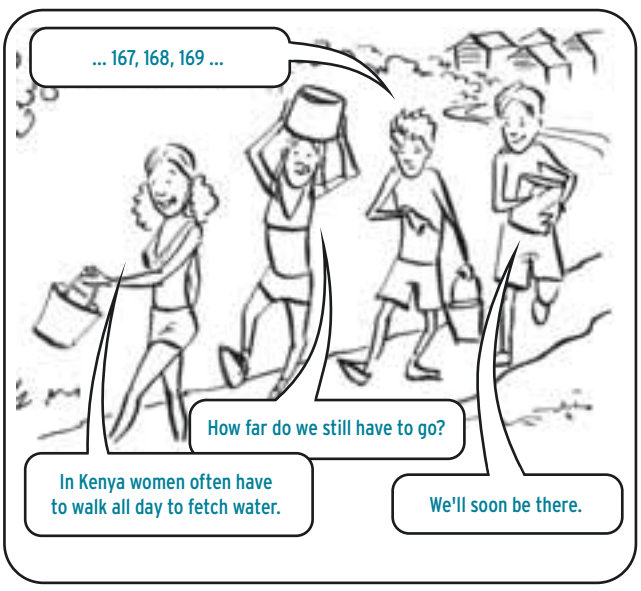
HIGH AND DRY

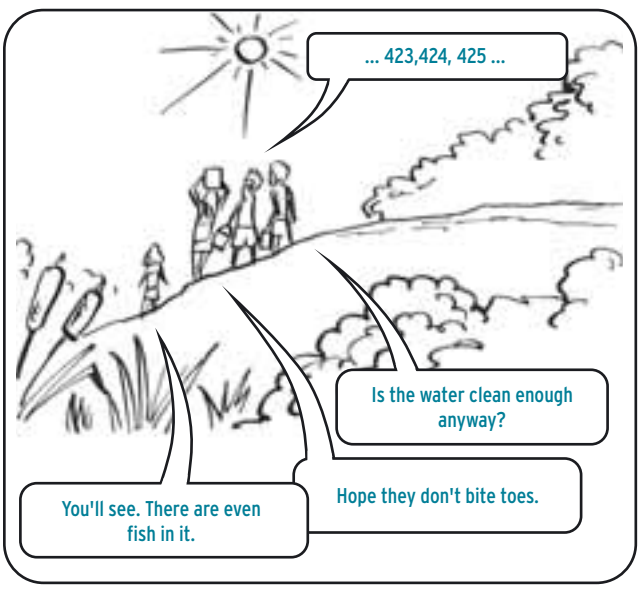
Framework Story for Water – Storyboard page 2/6





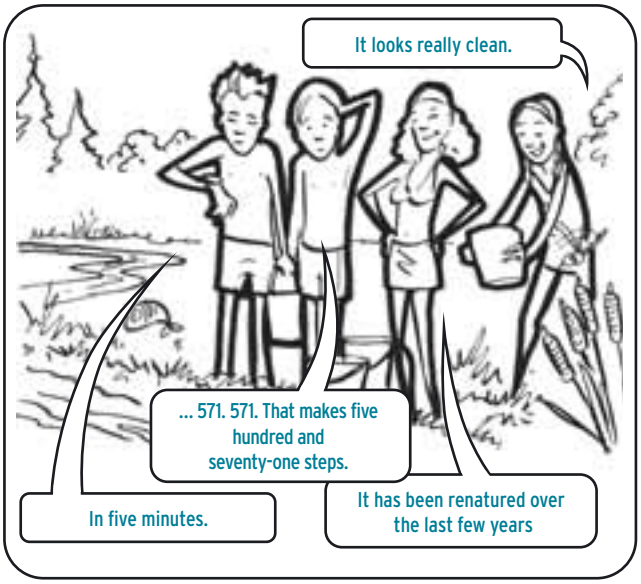


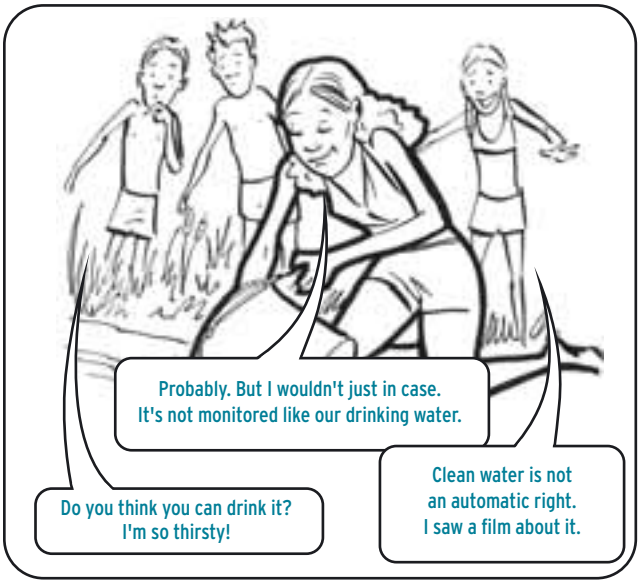


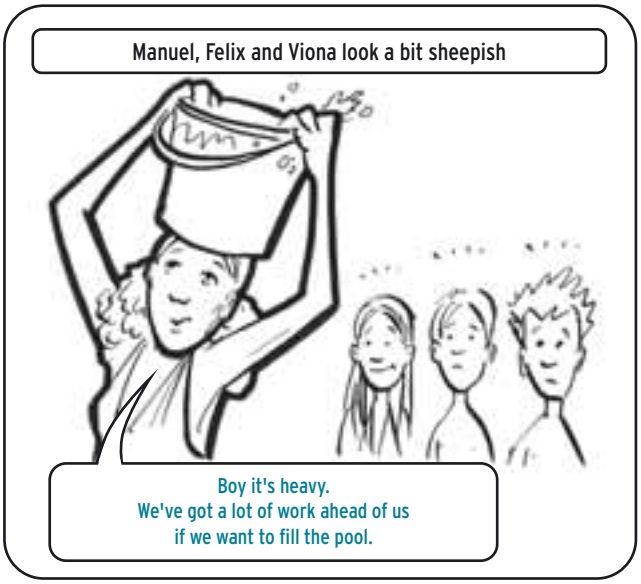


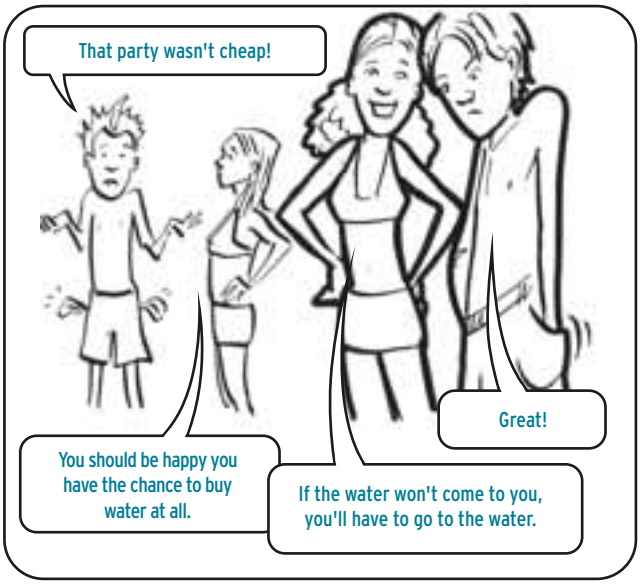
HIGH AND DRY

Framework Story for Water – Storyboard page 3/6



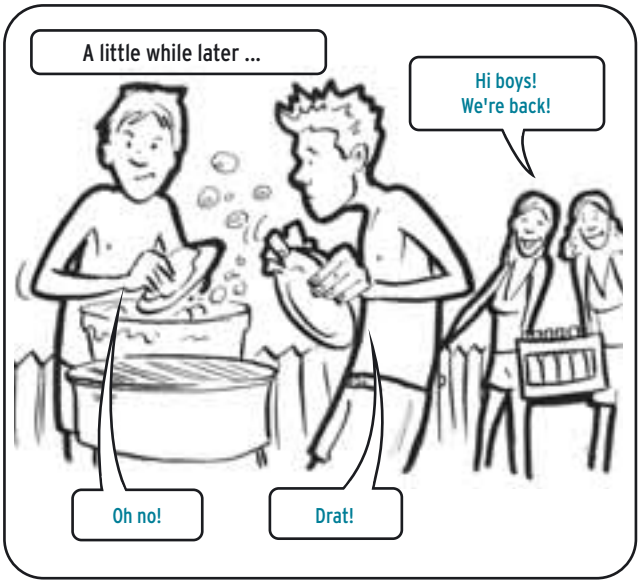


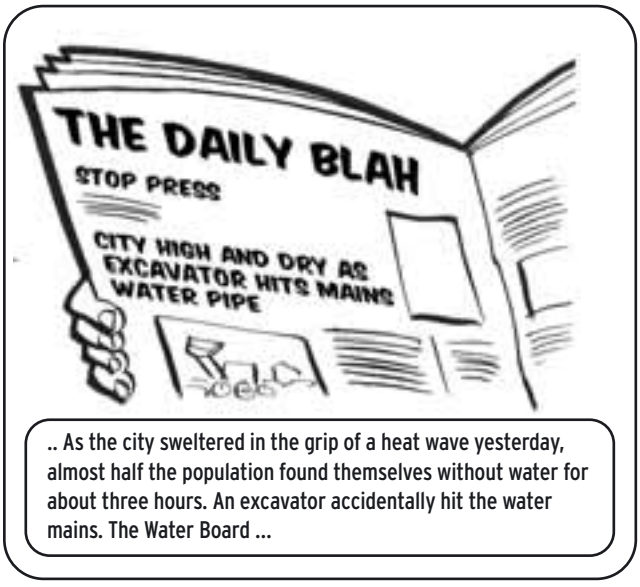




HIGH AND DRY

Framework Story for Water – Storyboard page 4/6





EXERCISES

1. The comic looks at various aspects of water. Read the story through carefully and list all the aspects you find. For example: one topic raised is the question of water supply.

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2. How much water does a paddling pool measuring 3 m in diameter and 1.50 m in height hold? To stop the pool overflowing it may only be filled up to a mark seven centimetres below the top. Round your result to the nearest hundred.

Tip: Use the following formula: $V = \pi \cdot r^2 \cdot h$

3. How long will it take the four friends to fetch the water, if each of them carries a 10-litre bucket from the stream to the allotment? Each trip takes 5 minutes and the pool is already half full when they start.

ANSWERS

Answer to Exercise 1:
Development aid and water; sudden water shortage (there's no water any more), water use (bathing, washing dishes), water transport (fetching water), water quality, renaturalisation, drinking water (water as a food), water supply (water pipes).

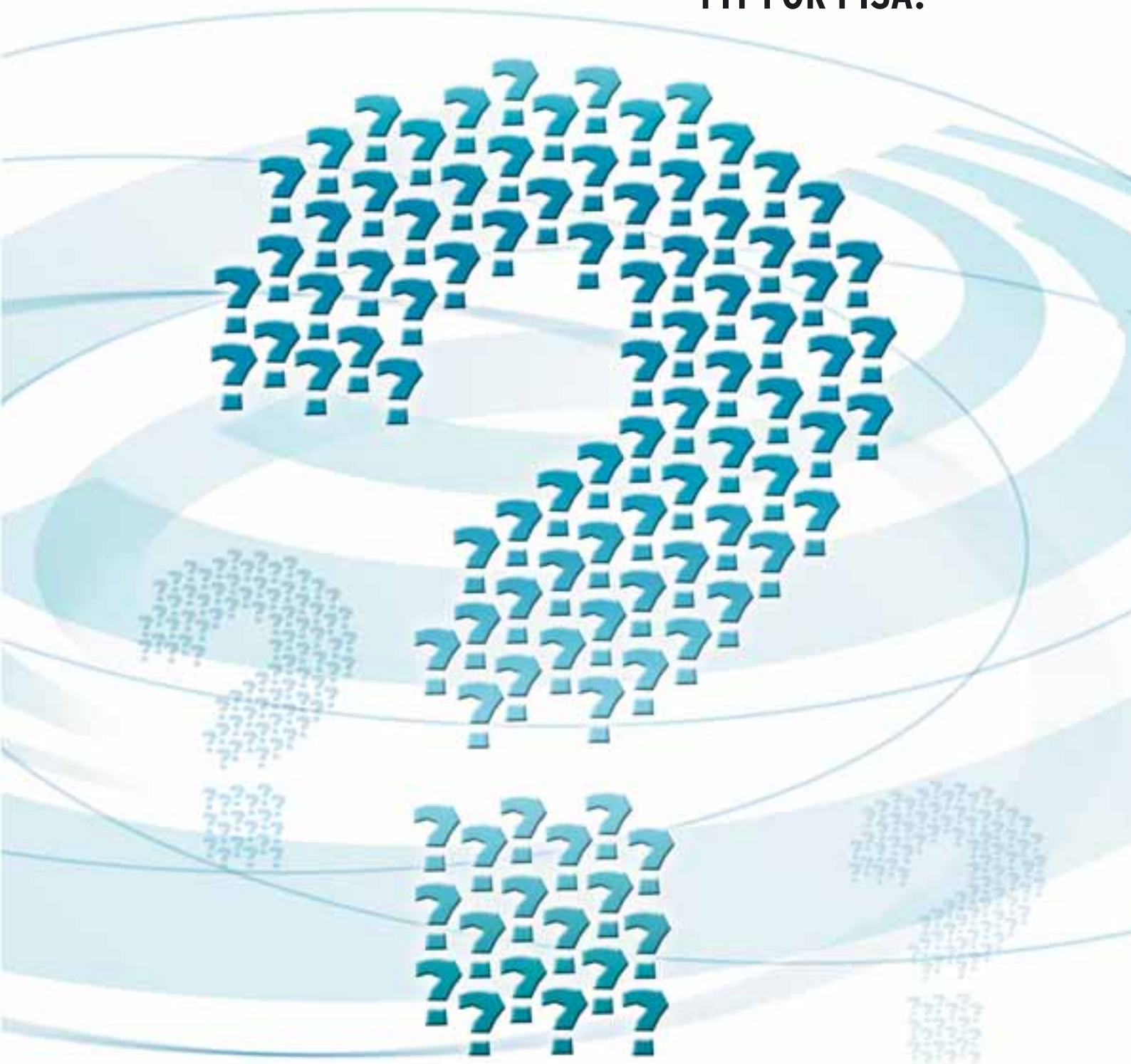
Answer to Exercise 2: $V = \pi \cdot (1{,}5\ m)^2 \cdot 1{,}43\ m = 10{,}108\ m^3 = 10.108$ litres
i.e. about 10.100 litres water

Answer to Exercise 3:

To half-fill the pool we need:	10.100 Liter x 0,5 = 5.050 litres
Four friends fetch water:	4 x 10 Liter = 40 litres
How often must they make the trip?	5.050 : 40 = 126,25 times
Time needed:	126,25 x 5 minutes = 631,25 minutes = about 10.5 hours!

LEARNING / COMPETENCE CHECK

FIT FOR PISA?



QUESTIONS

Question 1: The forest as a water filter

The government of Lower Franconia, in Bavaria, Germany, has published a leaflet on "Drinking Water for Lower Franconia", which states, "The forest is a good place to withdraw drinking water. In a forest no other forms of land use such as industry, agriculture or human settlements can directly jeopardise the groundwater. (...) Deciduous and mixed forests provide the best protection for the quality of drinking water. They filter pollutants from the air, absorb nitrogen, act as buffers for acids, and let naturally cleansed water enter groundwater reserves."

According to the text, which substances does the forest keep away from drinking water?

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Question 2

2.1 The blue planet

71 percent of the surface of the Earth is covered by water, which is why the Earth is sometimes referred to as the "blue planet". Why do many parts of the Earth still suffer water shortages? (There is more than one correct answer!)

- ☐ We need mostly freshwater.
  Freshwater accounts for only a few percent of the total water on Earth.
- ☐ Most freshwater is not directly accessible.
  Most freshwater can be found at the polar ice caps.
- ☐ Freshwater is distributed very unequally around the globe, and is expensive to transport.
- ☐ Most people live in the arid regions of the Earth.

2.2 Safe water

Currently four out of every five people on Earth have access to enough safe freshwater. How many people will still have enough freshwater in 2025 if water consumption continues to increase at the rate we have seen over the last twenty years?

- ☐ One person in fifty
- ☐ Two of every three people
- ☐ One in ten
- ☐ Every second person

Question 3: Virtual water

Water is needed to make products and to grow agricultural produce. Select the two items below which require the least water.

- ☐ One kilogramme tropical fruit
- ☐ One kilogramme rice
- ☐ One car
- ☐ One computer

Give reasons for your choice:

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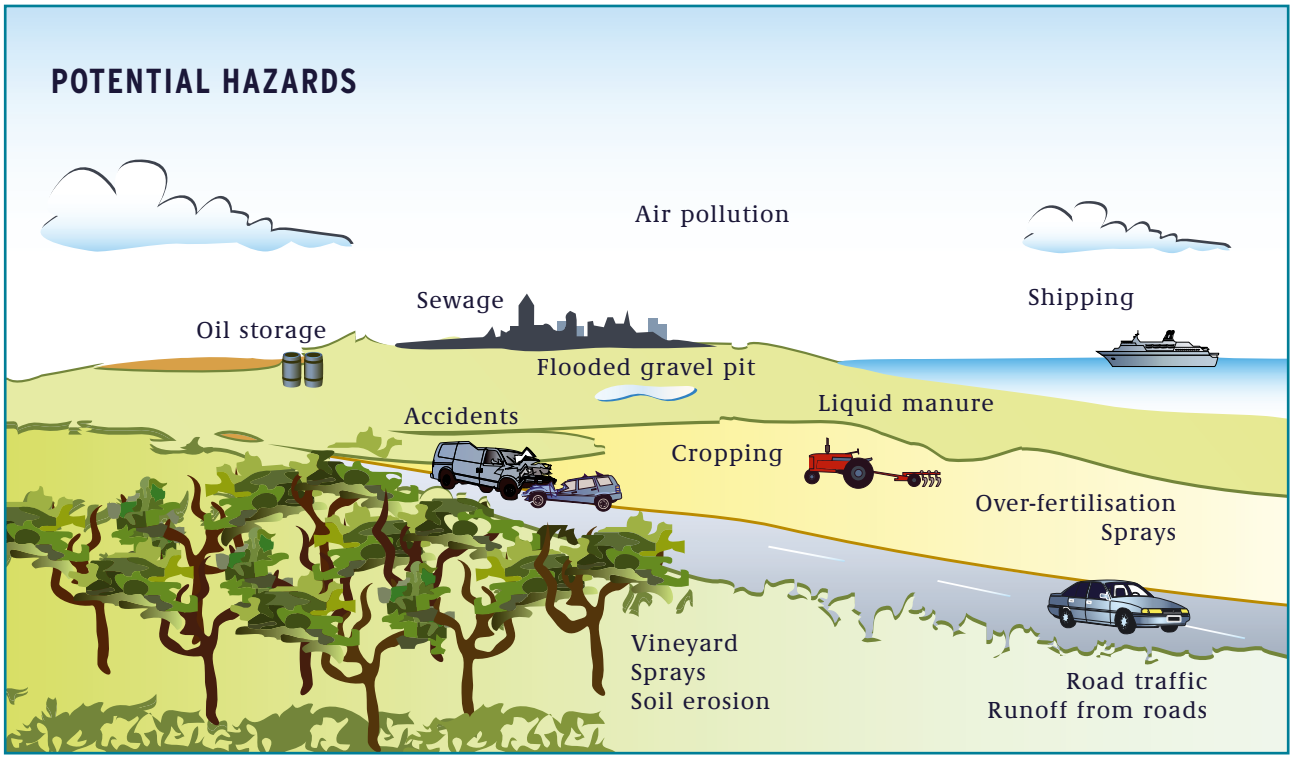
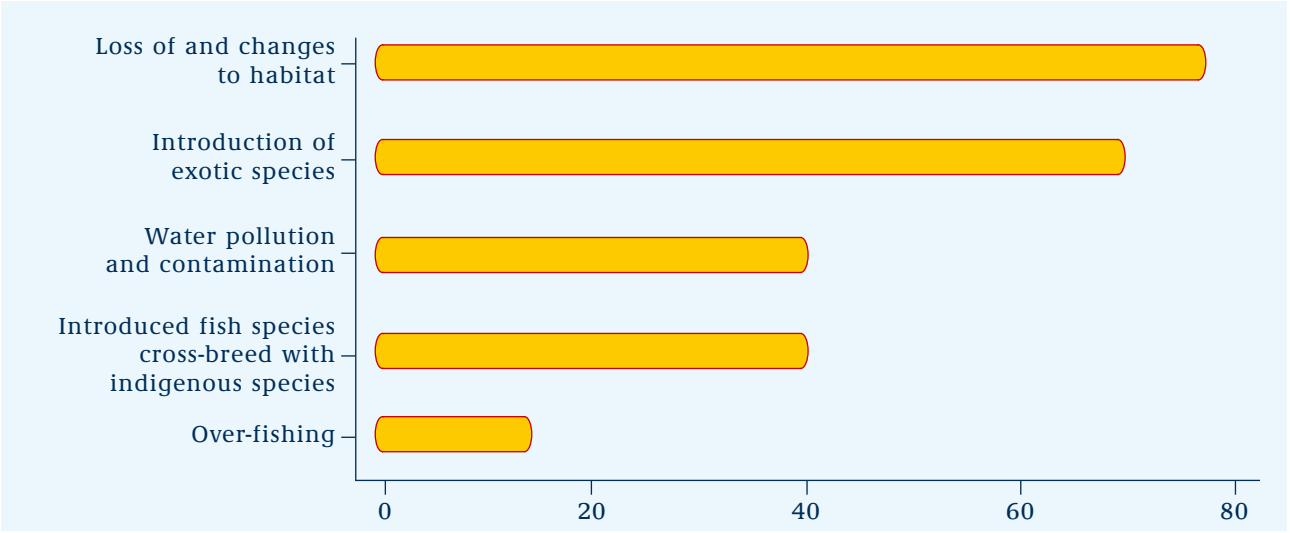
Question 4: Hazards for groundwater

The diagram below shows many potential hazards for groundwater. Identify as many as you can and put them into hazard categories.



Question 5:
Species loss

In many parts of the world, freshwater fish species are being lost. This is also true of North America. The following table shows the main causes of species loss among freshwater fish in North America over the last century.



Source: Miller, R.; William, J, Williams, J. (1989): Extinctions of North American Fishes During the Past Century. In: Fisheries 4, Vol. 6, 34-36.

1. Why has the introduction of exotic species led to the extinction of local fish species?

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2. The most important reasons for the loss of biodiversity among freshwater fish is habitat loss. The diagram above does not tell us how the habitats of freshwater fish have changed. What changes do you think could have led to species loss?

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3. Another important reason for the loss of biodiversity among freshwater fish is given in the diagram as water pollution. What forms of pollution of rivers, streams and lakes can you name? Be as precise as possible. Use the appropriate technical terms.

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ARE YOU AND YOUR PUPILS FIT FOR PISA?

The Education Service expressly offers information primarily on scientific, geographic and social studies topics. The aim is to give pupils modern scientific skills, with a view to enabling them to play a responsible, understanding and active part in today's and tomorrow's society. This corresponds to the competencies tested at international level within the framework of the PISA test. In line with this, test questions have been developed for the Education Service which are designed to allow teachers to assess the competence level attained by their pupils. The competencies to be acquired are very varied and demanding. The materials on this topic aim to develop the proactive skills of pupils. (See also: **www.blk-bonn.de > English**).

Our ideas today as to what constitutes a high-quality, practice-oriented, situation- and problem-appropriate basic scientific education (i.e. giving pupils scientific literacy), generally makes a distinction between the following fields, into which competencies can be categorised:

- Scientific concepts and principles (...)
- Methods of scientific investigation and scientific ways of thinking (...)
- Ideas as to what is special about sciences (...)
- Ideas as to the relations between science, technology and society (understanding of the "Science Business" in a social, economic and ecological context)
- Attitudes to and value-based decisions on the application of science and on nature as part of our living world.

The central facets of scientific literacy are:

Scientific processes – These are ways of thinking and working used by science (e.g. recognising that a problem can be tackled on a scientific basis, drawing appropriate conclusions on the basis of data and findings, the ability to explain something to others on the basis of scientific arguments, the ability to make predictions on the basis of data, interrelations and events).

Scientific concepts and subject matter – The topic fields and fields of application in which science offers facts and findings (e.g. forces and motion, evolution, the immune system).

In our modern understanding of science, the fields of application are considered to be very important. After all, the knowledge acquired is to be used in situations outside the classroom or laboratory. A distinction is made between individual, local or municipal and global importance.

A distinction is made between five competence levels:

Competence level I:
Nominal scientific literacy.
Pupils are able to draw conclusions on the basis of everyday scientific knowledge and can reproduce simple factual knowledge.

Competence level II:
Functional scientific literacy on the basis of everyday knowledge
Pupils are able to apply everyday scientific knowledge in order to make predictions or offer explanations. They can refer to scientific information in order to draw conclusions and assess these.

Competence level III:
Functional scientific literacy with the application of scientific knowledge
At this level pupils are able to use scientific concepts in order to explain phenomena and make predictions. They are able to decide which questions can be scientifically explored.

Competence level IV:
Conceptual and procedural scientific literacy
Pupils can identify and articulate additional information which they need in order to make valid conclusions. They can use relevant data in their chain of arguments and can communicate these. They can make use of elaborated scientific concepts to word predictions and offer explanations.

Competence level V:
High-level conceptual and procedural scientific literacy
Pupils can work with conceptual models and can systematically analyse experiments. They can take into account several different perspectives and argue in terms of one specific target group.

Competence levels IV and V differ in terms of the complexity, precision and systematic approach needed to resolve the problems set.

In the 2000 PISA Test of scientific literacy 60% of questions were multiple choice and 40% open format tasks. We have not chosen the same breakdown here, since multiple choice questions are very easy to produce and this is common practice. We have thus chosen to concentrate more on open format questions. For every topic area covered by the Education Service, questions are drawn up and classed in line with the above competence levels. This categorisation is based on assumptions of plausibility and is not intended to be taken as a gold standard. It should be seen as a suggestion, which teachers can and should adapt on the basis of their own experience. This also applies to the degree of difficulty involved in the exercises and the number of possible answers to some questions. In future, the Education Service plans to take into account concrete feedback from teachers with respect to the questions and exercises set. We would also like to point out the following:

1. In the PISA Test in 2000, German fifteen-year-olds (across all forms of secondary school) were clustered at the upper end of competence level II. Only 3.4% achieved competence level V, while 26% attained only competence level I (another 26% attained competence level II, 20% reached competence level III and 24% managed competence level IV).

2. It is not possible to cover every aspect of basic scientific literacy in one block of exercises. Several exercises would be needed for each aspect.

3. The individual questions contained in the exercises also require pupils to find and use information and skills that are not covered by these materials on water. This is customary and necessary when classifying competences in order to avoid too restrictive a link to the curriculum.

ANSWERS

Question 1: The forest as a water filter.

According to the text, which substances does the forest keep away from drinking water?

Purpose of the question:
Pupils should be able to identify information, and quote simple facts contained in the text. This corresponds to competence level I.

Correct answer:
- Pollutants from the air
- Nitrogen
- Acids

Question 2:

2.1 The blue planet.

71 percent of the surface of the Earth is covered by water, which is why the Earth is sometimes referred to as the ”blue planet“. Why do many parts of the Earth still suffer water shortages?

Purpose of the question:
Pupils should demonstrate an awareness of the problems regarding the quantity and accessibility of freshwater. The fact that there are several correct answers ensures that several different dimensions (geographical, scientific, economic) are taken into account. This corresponds to competence level II.

- ☒ We need mostly freshwater. Freshwater accounts for only a few percent of the total water on Earth. Only 2.5 % of global water reserves are freshwater.
- ☒ Most freshwater is not directly accessible. The largest percentage of freshwater can be found at the polar ice caps. Only a few hundredths of the total freshwater reserves are directly accessible. Freshwater can be found in the atmosphere, in low-lying layers under the surface of the Earth and in the polar ice caps as well as in glaciers. Harnessing this water is costly and time-consuming.
- ☒ Freshwater is distributed very unequally around the globe, and is expensive to transport. The long transport routes make it impractical to try to move water from areas where it is plentiful to areas suffering shortages. It does not make any ecological sense, either.
- ☐ Most people live in the arid regions of the Earth. No, few people live in the arid parts of the world.

2.2 Safe water

Currently four out of every five people on Earth have access to enough safe freshwater. How many people will still have enough freshwater in 2025 if water consumption continues to increase at the rate we have seen over the last twenty years?

- ☐ One person in fifty
- ☒ Two of every three people
- ☐ One in ten
- ☐ Every second person

In the Millennium Development Goals, the United Nations set itself the goal of halving the number of people with no sustainable access to safe drinking water (currently 1.2 billion people) by 2015. The chances of achieving this goal are slim, since freshwater is becoming increasingly scarce as per capita consumption rises (especially because of agriculture and industry).

Question 3: Virtual water

Water is needed to make products and to grow agricultural produce. Select the two items below which require the least water.

Purpose of the question:
Pupils should demonstrate that they understand the concept of virtual water consumption not only by estimating the amount of virtual water contained in various products. They should also be able to recognise a rule. This corresponds to competence level III.

- ☒ For one kilogramme tropical fruit
  About 1,000 litres water are needed per kilogram.
- ☒ For one kilogramme rice
  About 3,000 litres water are needed per kilogram.
- ☐ For one car
  About 400,000 litres water are needed.
- ☐ To manufacture one computer
  About 5,000 litres water are needed.

Give reasons for your choice:
Large industrially manufactured products based on metals and plastics generally use significantly more water than agricultural produce, because the extraction and processing of raw materials is very water-intensive.

Question 4: Hazards for groundwater

Purpose of the question:
Pupils should be able not only to identify hazards for groundwater with the help of the diagram, but to class these systematically. Several sources must be explored. Pupils must not only recognise the links between agriculture, industry, traffic and hazards to groundwater, but must be able to systematically group apparently unrelated sources (fertilisers, lack of forest cover). The more individual aspects listed under the four sources below, the better the pupil performance. This corresponds to competence level IV.

Correct answer:
1. Agriculture, horticulture (including vineyards) because of water withdrawal, fertilisers, pesticides, soil compacting through the use of heavy machinery, low level of forest cover
2. Industry (water withdrawals, pollutants such as heavy metals which enter groundwater through leaching for example from contaminated industrial sites, raw materials extraction (in this case gravel), air pollutants, inputs for machinery, removal of protective soil layers, lowering of the groundwater table, e.g. in the case of mining, uncovering groundwater with the risks of evaporation and contamination)
3. Traffic and transport: (sealing off the surface of areas of land, oil, tyre abrasion, brake abrasion, air pollutants, which are then washed into the soil by rain, lowering of the groundwater table for large-scale projects such as underground railway construction, large railway stations, airports), accidents involving hazardous goods transporters
4. Human settlements: (sealing off the surface of areas of land, air pollutants, leakages from tanks and sewage pipes, fertilisers and pesticides from private gardens, varnishes and paints, solvents, acids and bases, lowering of the groundwater table for construction projects)
5. (If relevant: filling in the gravel pit with unsuitable materials)

Question 5: Species loss

Purpose of the question:

Pupils should establish a systematic link between the information contained in the diagram and the causes of species loss. They will have to study the graph precisely, since not all figures are needed to answer the question. Since they are asked to use the technical terms, they will be required to demonstrate a higher competence level than when putting the hazards for groundwater into systematic categories (Question 4). This corresponds to competence level V.

Correct answers:

1. Why has the introduction of exotic species led to the extinction of local fish species?

Exotic species can force indigenous species out of their own biotope (they might compete for food or eat the indigenous species) or can change the existing biocenosis such that the communities of indigenous species are destroyed. The graph provides another hint. Cross-breeding between indigenous and exotic species can lead to the loss of indigenous species.

2. List the ways in which fish in rivers and lakes can lose their habitat.

Straightening rivers, draining wetlands, building dykes, building dams and embankments, pollutants (see diagram: water pollution and contamination); use of rivers and lakes for transport (deepening the shipping channel, changes in bank consolidation, mechanical forces acting on riverbanks and coasts caused by the wake of ships); leisure activities disturb fauna.

3. What forms of pollution of rivers, streams and lakes can you name? Be as precise as possible. Use the appropriate technical terms.

Fertiliser run-off, in particular nitrogen from agriculture which results in nitrates entering the groundwater; pesticides, herbicides; residues of cleaning materials (including surfactants), metals (arsenic, chrome, cadmium, copper, lead, mercury, manganese, zinc), oil, salts, chemicals, acids, domestic waste, untreated sewage (faecal matter), exhaust fumes from the air dissolved in rainwater, tyre abrasion.

BACKGROUND INFORMATION FOR TEACHERS

Under the provisions of the EU Water Framework Directive, all EU member states were required to record the status of their water resources by the end of 2004 and to report to the European Commission by March 2005. The inventory also covered all surface water, including rivers. On the basis of this inventory, monitoring programmes were devised. The results of monitoring are now being used to class all rivers according to water quality categories. Where rivers do not yet meet the quality requirements laid down in the EU Water Framework Directive, steps must be taken to improve quality. This relates not only to the chemical quality of the rivers, i.e. the level of contamination by pollutants, but also and more importantly to the animals and plants living in the water. Their habitat is to be restored to as natural a state as possible.

The EU Water Framework Directive looks at rivers from completely new points of view. It is not the borders of federal states or nation states that are important, but the river basin as a whole. This means taking a holistic view of natural water systems and how they are used from the source to the estuary. The water cycle links rivers and groundwater. When they flood, rivers raise the groundwater table, and conversely when water levels are low in rivers, they are fed by groundwater. Groundwater is our most important drinking water reservoir, and another of the goals of the EU Water Framework Directive is to protect it.

N.B.

Information Sheet 1 provides you and your pupils with an overview of the main contents and objectives of the EU Water Framework Directive. The directive aims to translate into specific requirements the term ”sustainability“ as it relates to the field of water resources management. With this directive it is hoped that good water quality can be achieved across the board by 2015. Sustainability goes further than merely requiring good chemical and biological quality of the water. It looks at the status of the body of water in its entirety, river beds and banks, adjacent flood plains and all tributaries and related bodies of water that make up the river basin as a whole. The legal mandate to protect water quality entails improving wastewater disposal systems at municipal and household level and reducing pollution caused by agriculture, smallholdings, etc. Running water and the surrounding environment are to be restored and rehabilitated. Back-to-nature maintenance and restoration measures that encourage natural development are appropriate parallel steps here, as is the establishment of protection strips along the courses of streams and rivers. This makes it possible to preserve and restore the habitats of flora and fauna. Water protection is, however, not only the duty of the central government. Every one of us can help, for instance, by sponsoring individual bodies of water or parts thereof. In some federal states in Germany, dedicated citizens and experts work together in what are known as ”Water Neighbourhood Schemes“ to preserve and enhance the quality of water resources. You can take a critical look at the objectives of the EU Water Framework Directive to give pupils a tangible experience of education for sustainable development, as related to water protection.

GOAL

Set 1 (”Living Rivers“) of the instruction module on water indicates the importance of the relations between human beings and the rivers along which they settle. The mutual influences and resulting ecological conflicts are presented and worked through. These include the topics wastewater/threat to water quality, flooding and the correlation between these and an inappropriate morphological state of river areas (as a result of river engineering). Pupils can work through the river renaturing process at the end of the unit, taking into account the demands posed by the three factors utilisation, water quality and morphological quality. In terms of scientific literacy, pupils learn to apply their newly acquired scientific knowledge to the field of water. They should be able to recognise the scientific problems involved (threats to rivers and threats posed by rivers) and should be able to draw conclusions on this basis, which will help them make decisions regarding their own everyday behaviour patterns.

POINTS OF CONTACT WITH THE SYLLABUS

- Water – the basis for life
- Insight into the impacts of interventions in the natural balance: water resources, groundwater, lowering of the groundwater table, land reclamation, steppisation, waterlogging, salinisation
- Water – an unusual substance, importance for life on Earth and the environment
- Water in balance: drinking water, process water, wastewater
- Water and sanitation (producing drinking water and treating wastewater)
- Environmental protection in the community: including dealing with water consumption, water catchment
- Water for the industrialised society: Industrial and domestic water consumption and pollution, sealing land surfaces and lowering the groundwater table
- Rivers – a habitat for flora and fauna, biodiversity, the food chain and food network
- People change their environment: Problems: Soil erosion, deforestation, flood risk
- Water resources management: Water resources, water treatment/ water pollution and keeping water clean
- Various water treatment methods (e.g. sewage plant, biological treatment plant)
- Flooding – a threat to the human population
- Renaturing rivers – a solution to the flooding problem?

METHODS

Use proactive and problem-oriented interdisciplinary lessons, with independent learning in groups. Groups can each look at a different aspect of the material or can all work on the same aspect. The materials can be used for pupils, age 14 – 16, in geography, biology, chemistry, mathematics, social studies or political studies.

CONTENTS AND RELATED LEARNING GOALS

The pupils look firstly at the importance of rivers for people. They learn that the courses of rivers are used for human settlement and economic activities. Rivers supply water for drinking and other uses. They provide food, transport routes and many other things. The influence of people on rivers and vice versa is presented, and the resulting ecological conflicts are explored. These should include flooding, which has become extremely topical over the last few years, and the correlation between an inappropriate morphological state (as a result of river engineering) and flooding. Pupils should learn about ways of resolving these problems and should realise the importance of renaturing measures which meet the requirements of the three fields of water utilisation, water quality and morphological quality.

Learning goals in terms of *Gestaltungskompetenz*[1]/key competences as laid out by the OECD:

Pupils learn to apply their newly acquired scientific knowledge to the topic of rivers. They recognise the scientific problems involved (threats to rivers, threats posed by rivers) and can use this knowledge to draw conclusions that will help them make decisions regarding their own everyday behaviour patterns.

The following sections of the OECD key competencies or sub-competencies of *Gestaltungskompetenz* are targeted:

- The ability to draw interdisciplinary conclusions and act on an interdisciplinary basis: interdisciplinary view of a subject, identifying problems and devising solutions. Pupils bring their scientific knowledge and apply it to a specific problem. They combine innovative technical knowledge and a planning strategy.
- The ability to plan and act with others (group work)
- The ability to motivate oneself to act (transfer phase)
- The ability to motivate others to act (transfer phase)
- The ability to plan and act independently (group work)

SUGGESTED APPROACH

Phase One – Rivers as a Lifeline

Worksheet 1:

As an introduction to the topic, organise a brainstorming session with pupils on the importance of rivers and how we use them. Pupils should gather all aspects of the importance of rivers for people. If the town or village the pupils live in happens to be on a river you could organise a field trip to the river and perhaps also poll passers-by on the uses of "their" river. You could also contact the relevant authorities. The results should be put together in group work, presented to the class as a whole, documented (for instance in the form of loose-leaf files, posters, wall newspapers) and compared with one another.

[1] Since Germany's low results in Pisa, the development of "*Gestaltungskompetenzen*" has been a very important topic. To explain "Gestaltungskompetenz" is by no means an easy task, as the concept includes many facets and layers. It is the ability to identify problems of sustainable and non-sustainable development and to apply knowledge about sustainable development. Furthermore, pupils should learn to draw conclusions from current analyses and forecast about ecological, economical, and social developments and their mutual dependence. Last but not least, they should be able to make, to understand and to implement decisions based on the analyses. www.managenergy.net/conference/pdfs/0505education.pdf

Phase Two – Going into more depth – Drinking water supply and wastewater disposal

Worksheet 2 (group work):
Pupils should be divided into groups of two or three and work on the exercises shown for Worksheet 2. It might make sense to give the groups different assignments, so that each group looks at different concepts. To help them find the information they need, you will have to provide them with school textbooks and information sheets. The other exercises should not be tackled until the pupils have presented their results for Exercise 1. The other results should be discussed and evaluated and perhaps documented in the form of a wall newspaper (or a loose-leaf file which the pupils should put together).

Phase 3 – The problems of flooding

Worksheet 3 (group work):
Pupils should get into small groups and do the exercises from Worksheet 3 together. It is important that you tell them where and how they can find the information they need. You could encourage the pupils to identify research options themselves before the group work session. (They could, for instance, contact relevant authorities such as environmental agencies, water and shipping authorities, identify relevant NGOs, use the Internet, visit the local library, etc.) Exercise 3 can be broken down such that each group explores and presents one specific flood protection method. The results of the group work should be documented and evaluated by the entire class. You should tell your pupils that in Germany, planning instruments exist which can be consulted on the premises of the relevant authority (identification of flooding zones, flood risk maps, etc.). You can find more information on what landscape planning, nature conservation and landscape preservation can do to prevent flooding, on the website of the German Federal Environment Agency (UBA).
www.umweltbundesamt.de > English > flooding

Phase Four – River engineering and renaturing

Worksheet 4, Information Sheet 1:
Worksheet 4 introduces pupils to the problems of technical interventions in rivers (culverting, channelisation, reinforcement, etc.) and the consequences of these. After you look at the problem "What does the river do for us?", you should ask pupils, "How have we changed the river?". The way we use rivers calls for numerous interventions in the river system, which has led for instance to changes in the natural flow of rivers and to obstacles to the flow. This has seriously impaired the function of rivers as an essential artery within the natural balance. The biodiversity found in a natural river is lost. To illustrate the problem clearly to pupils, it is a good idea to organise a field trip to a large stream or river at this point. Information Sheet 2 gives you an overview of the major characteristics of a river with a sound ecological status. It is important that the pupils record the findings of their field trip. They should make a note of everything they notice with regard to possible anthropogenic interventions in and around the river. They should then assess their observations, and consider whether the situation on the ground can be improved, and if so, how. The results should be assessed by the entire class. If possible, the class should present its results to a representative of the local government, the mayor, the authority responsible or a local NGO. It might even be possible to launch a joint renaturing project.

Worksheet 5 – Passability of running water:
The last worksheet will teach pupils that it is important to take a holistic view of running water in particular. Most indigenous river fish species in Europe migrate. In particular those species that migrate to spawn depend on being able to swim freely up and down rivers and on the networking of the river with related habitats. To preserve fish species it is thus important, along with clean water, to have a rich structure of water biotopes, which fish can access freely. The drop in fish stocks in rivers and streams is partly the result of some massive obstacles built in the path of the

river. Weirs and sluices, hydropower plants and locks prevent the free migration of fish. Since migrating fish cannot overcome these obstacles, effective ”ring roads“, such as fish ladders, must be built for the fish, in order to mitigate the consequences of the blockages. On the basis of these problems you can instigate an in-depth discussion of economic versus ecological imperatives. What is more important, for instance: The use of hydropower, which is after all a renewable energy source, or protecting fish in the rivers? As the example of the fish ladder shows, it need not necessarily be a question of ”either/or“. The various technical systems available to help fish pass obstacles make it possible to reconcile the economic and ecological considerations, although there is a price to be paid. It is, for instance, very expensive to backfit or modify hydropower plants. But if we aim to preserve fish stocks or reintroduce fish species, there is no alternative.

Go on a field trip to a local river so that pupils can investigate for themselves whether barriers exist that block the routes of migrating fish species, and if so in what form. They should consider the following questions: How far can fish swim unobstructed? Where do the fish spawn, or how could spawning grounds be recreated, and how do fish get there? Do locks and hydropower plants have effective fish ladders? Where are improvements needed? Contact local water authorities to obtain more information. Local angling clubs are often another good source of information on the problems, and will probably be happy to help you.

N.B./Further transfer:
It might be possible to put together all the materials gathered for the lesson unit and organise a small exhibition in the school, to coincide with a school open day or parents' evening, or to present the materials to the other classes. After all, your pupils are now experts in the field of ”living rivers“.

MATERIALS

- **Comic strip**
- **Worksheets 1 to 5**
- **Background information for teachers**
- **Information sheet 1: The EU Water Framework Directive**
- **Information sheets 2 and 3: What is a living river?**

ANSWERS TO THE WORKSHEET EXERCISES AND HELPFUL HINTS

Worksheet 1:

Exercise 2: Leisure/recreation, traffic and transport, water for drinking and other uses, wastewater, agriculture, quality of life
Exercise 3: Running water as a habitat for fish, other water creatures and plants, the river bank biotope, ecosystems, flood plains

Worksheet 2:

Exercise 2: Drinking water well – water treatment – water connections for industry and households – sewage pipes, treatment in sewage treatment plants – discharging the treated water into the river
Exercise 3: Under the provisions of the German Drinking Water Ordinance, the quality of drinking water must be such that it will have no negative consequences on the health of an individual drinking 2 – 3 litres of the water every day for a lifetime.
Grey water is the term used to describe water that has been used for bathing, showering and washing. Drinking water used in this way becomes grey water.
Raw water is untreated water, delivered to a purification plant to be made into drinking water.

Exercise 4: Use of power, chemicals (chorine, ozone, fluorine), maintenance costs, technical costs

N.B.:
At this stage you should point out the need to protect surface water and groundwater from pollutants. Since this topic is already dealt with in the relevant syllabuses and textbooks, we have not explored it again separately here.

Worksheet 3:

Exercise 1: On the right-hand map, the flood zone covers the whole area shown on the left-hand map as the river system with its lateral branches, old branches and abandoned river courses. You should not build on this area, because annual flooding can be expected there. The maps show that the meandering course of the river no longer exists. Neither do the oxbows and old branches of former times. These areas have now been built on. Pupils should realise that the risk of flooding affects the area which was still marked as river land on the 1825 map.

Exercise 2: Water authorities, local nature conservation authorities, environmental agencies
Exercise 3: When looking at what can be done to prevent flooding, pupils should realise that building dykes is not the only option. Ecological measures, such as establishing retention areas and renaturing should be mentioned, along with limiting the potential for damage in flooding zones.

The main reasons for flooding

1. People settle too close to the river, precisely in those places where the river would naturally burst its banks when water levels are particularly high.
2. River engineering is a particularly thorny issue, straightening the courses of streams and rivers, reinforcing banks and building embankments, and dredging the riverbed. This increases the rate of water flow and the flood wave flows downstream much more rapidly, thus increasing the risk of flooding for those settlements on the lower course of the river. We have merely substituted one problem for another.
3. Intensive settlement means that the surface of too much land in a river catchment area is sealed with asphalt and concrete. The soil becomes impermeable, and rainwater can no longer seep through it. Surface run-off is increased.
4. Major areas along the streams and rivers are farmed intensively. This compresses the soil and prevents water from seeping away.

Worksheet 4:

Exercise 1a: Left-hand picture; **1b:** Right-hand picture
Exercise 2: Additional arguments: e.g. settlements, sustainability, land use, restrictions on land use, drinking water, flora and fauna

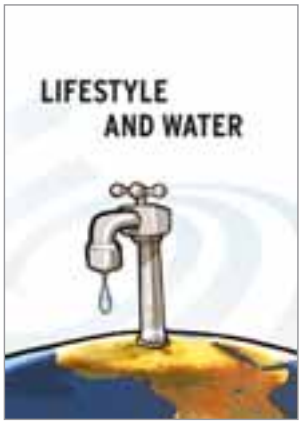
Worksheet 5:

Exercise 1: At the first hydropower plant and at the weir
Exercise 2: One possibility would be to build a ”ring road“ as you can see at the lock. Using the Internet links given, look at the various forms of fish ladders that can be built.

General information

www.bmu.de > English > Topics > Water
www.umweltbundesamt.de > English > Search: Water

BACKGROUND INFORMATION FOR TEACHERS



An adequate supply of water is a basic human need. Every individual uses several thousand litres of freshwater every day, directly (in the form of drinking water) and indirectly (the water used to produce food and industrial goods). The World Health Organisation (WHO) considers a daily per capita water consumption of 100 litres to be an absolute minimum requirement. While the quantity of water consumed directly is relatively low, significantly more is used to produce the food we eat. Irrigating one hectare of land in an arid region can use up to 10,000 cubic metres of water (i.e. 10 million litres) per annum. Agriculture is the largest consumer of water worldwide. In countries where a high percentage of cropland is irrigated, agriculture can account for more than 80 percent of total water consumption.

Currently about one third of the world's population lives in countries suffering a medium, high or very high level of water stress. By 2025, according to the figures of the International Water Management Institute, some 40 countries, with a total population of almost 2 billion, will be suffering serious water shortages. Rarely, however, do we think about how much water people in industrialised countries with their modern lifestyle consume indirectly. This is significantly higher than their direct consumption. With coffee, orange juice and many other agricultural products, they import ”virtual water“. Virtual water is a relatively new term, used to describe water used to manufacture or grow a product.

GOAL

The materials on the topic of ”Lifestyle and Water“ should be used independently by the pupils to acquire knowledge about ”The water of the Earth“ (Worksheet 1), ”How much water do we really need?“ (Worksheet 2), ”Is there enough water for everyone?“ (Worksheet 3), ”In the beginning there was the village ...“ (Worksheet 4), by using interactive media and materials as called for by the OECD competence levels. They should make use of the information contained in the worksheets and information sheets, interpret thematic maps and conduct their own online research to obtain additional information on the topics. The next step for them is to deliberate on their own lifestyle. They should be introduced to the still relatively little known notion that people in prosperous industrialised countries affect the water resources in developing countries by their virtual water imports (Worksheet 5). Pupils should review their own lifestyle on the basis of selected products (bananas, coffee, orange juice, for instance) to see how much they contribute to the consumption of virtual water from developing countries (Worksheets 6 and 7). In terms of scientific literacy, they thus learn to apply their newly acquired scientific knowledge to the field of lifestyle and water. They recognise scientific problems (and possible solutions) and can draw conclusions that will help them make decisions regarding their own everyday behaviour patterns (OECD competence field ”independent activities“).

POINTS OF CONTACT WITH THE SYLLABUS

- Water – a scarce commodity: How water is wasted in industry, agriculture and private households, the causes of water shortages, deforestation and erosion, sealing off the soil, over-grazing, exploiting groundwater resources
- Exhausting natural resources (air, water, soil, raw materials)
- Water – the basis for life and habitats
- Water, an unusual substance, importance for life and the environment
- National water consumption and the global water crisis
- Transnational problems in water supplies and water pollution

METHODS

Use proactive, interdisciplinary lessons. Pupils should acquire knowledge independently by working at various stations, and through individual, partner and group activities. They should produce short papers and presentations for the class. Organise group discussions and use scenario techniques.

Suitable for: Age 14 - 16

Subjects: biology, geography, mathematics, physics, social studies, ecology, political studies, economics, civics

CONTENTS

The four main characters introduce the topic. Pupils learn firstly about how water is distributed on Earth and what a tiny percentage of total water reserves is accounted for by accessible freshwater (Worksheet 1). They find out about drinking water and look at ”lifestyle and water“ around the globe, taking as their starting point the wide discrepancies in water consumption (Worksheet 2). Access to this valuable resource is extremely inequitable, for various reasons. In future it is to be expected that worldwide water shortages will become more acute (Worksheet 3). The problems caused by the lack of even basic sanitation in many countries, and the disastrous impacts thereof on human health are touched on in Worksheet 4. One important aspect of the global water situation is the importing of so-called ”virtual water“ by industrialised countries with the agricultural produce they import from developing countries already suffering water shortages. Worksheet 5 introduces pupils to this concept. They discover which agricultural products from developing countries are sold in Germany (Worksheet 6). They should keep a food record based on their own eating habits, to establish how much virtual water is imported from developing countries, which all too often have problems ensuring an adequate water supply for their own people (Worksheet 7). Thereafter pupils should go on to look at possible alternatives to the problems discussed. They should reflect on their own purchasing and consumption patterns and, if appropriate, look at how they could change these. They should also discuss the problems on the basis of fundamental values.

N.B.
The term ”water consumption“ is used frequently in the text. Strictly speaking we should use the terms ”water demand” or ”water use”, but since the relevant school textbooks and literature (especially online) use the term ”water consumption“, and pupils are more likely to be familiar with this term, we have decided to use it to facilitate understanding. We recommend that you explain the different terms and concepts in your lesson, perhaps as an introduction to the topic. Discuss with your pupils how the three terms are used, for instance by asking them whether water can in fact be consumed.

The two information sheets will give you and your pupils an insight into the topics ”The Global Water Situation“ and ”Virtual Water“.

LEARNING GOALS

Pupils should become familiar with and understand the problems involved in the enormous amount of water we use as a result of our lifestyle. They should devise ways of overcoming these problems. They should be introduced to important aspects of the issue, such as differing access to water from one country to another and virtual water imports. A critical look at their own lifestyle in terms of consumption should bring them to consider alternatives. At the end of the unit they should produce a pamphlet that gives advice on the topic of ”Lifestyle and Water“. It should provide information on the global water crisis and tips and recommendations regarding personal consumption patterns (see also the section on the transfer phase).

Learning goals in terms of *Gestaltungskompetenz*[1]/key competences as laid out by the OECD:
The following sections of the OECD key competencies or sub-competencies of *Gestaltungskompetenz* are targeted:

Interactive utilisation of media and tools:
- Building knowledge to integrate new perspectives, with an open mind,
  - Pupils find information independently using a variety of materials and media on the topic area ”Lifestyle and Water“,
  - Pupils present different points of view and forms of knowledge about global (non)-sustainable developments (virtual water, lifestyle) on the basis of the new perspectives they have come to know,
- The ability to acquire and handle interdisciplinary knowledge,
  - Pupils work on an interdisciplinary basis on a project. They apply scientific knowledge and principles to a specific problem. They link innovative technical knowledge and planning strategies,
- The ability to anticipate,
  - Pupils identify the symptoms of the global water crisis and recognise the consequences,
- Transferring and applying what has been learned,
  - Pupils design options for action and ideas in order to improve the situation.

[1] Since Germany’s low results in Pisa, the development of ”Gestaltungskompetenzen” has been a very important topic. To explain ”Gestaltungskompetenz” is by no means an easy task, as the concept includes many facets and layers. It is the ability to identify problems of sustainable and non-sustainable development and to apply knowledge about sustainable development. Furthermore, pupils should learn to draw conclusions from current analyses and forecast about ecological, economical, and social developments and their mutual dependence. Last but not least, they should be able to make, to understand and to implement decisions based on the analyses. www.managenergy.net/conference/pdfs/0505education.pdf

Interacting in heterogeneous groups:
- The ability to plan and act with others (group work),
- In group work, pupils can identify and analyse different points of view as well as dealing democratically with controversies arising in this context (discussion),
- Pupils learn to motivate others to play an active part (producing their pamphlet on "Water and Lifestyle" and presenting it to others).

Acting independently:
- Pupils reflect on their own guiding visions and those of others (Worksheets 6 and 7; own water consumption/ own consumer patterns)
- They acquire experience in independent planning and action (implementation of a sustainability project),
- They are able to empathise and demonstrate solidarity with the disadvantaged, the poor, the weak and the oppressed (recognise the situation in water-poor countries and the problems these nations face, develop an understanding).

SUGGESTED APPROACH

Introduction/ overview:
A comic strip on the topic of "Lifestyle and Water" with the familiar characters Viona, Manuel, Felix and Aysche.

Transfer phase:
Pupils collect and discuss their results in groups or with a partner. They should be given the following instructions: "Think together about the opportunities you have to reduce your consumption of virtual water. Draw up a list of your ideas. Which ideas do you think are good, and which are not so good? Think about how you could present your ideas to the class." (See Worksheet 7.) The results of this partner/group work session should be discussed by the class as a whole.

N.B.
We suggest that you get your pupils to produce a pamphlet with tips on how to change lifestyle and consumer patterns, which can be used by a wider audience. As they work on this guide, pupils will reflect on their work and focus again on what they have learned. A few points should be borne in mind: The aim is not to preach to the reader about the evils of consumption in general, but to point out the consequences of their actions. Pupils should then make an effort to propose creative solutions in their pamphlet. In this context it is also a good idea to identify future trends with your pupils using scenario techniques. You will find information on this method in the teaching materials on "Climate Change" available from the online Education Service of the Federal Environment Ministry (www.bmu.de/bildungsservice).

MATERIALS

- **Worksheets 1 to 7**
- **Information sheets 1 and 2**
- **Background information for teachers**
- **Stations pass**

ANSWERS TO THE WORKSHEET EXERCISES AND HELPFUL HINTS

Worksheet 1:

Exercise 1: Water with a very low salt content (lower than 1 g salt /kg water) is termed freshwater.

Exercise 2: The percentage is 0.3%.

Exercise 3: Freshwater is found in solid form as ice in glaciers and at the polar ice caps, as permanent ice and snow at high altitudes in mountains and occasionally at lower altitudes (in winter). Freshwater occurs in liquid form in surface bodies of water such as streams, rivers and lakes and as underground water (groundwater). It is also found in clouds and in precipitation (rain, snow, hailstones).

Exercise 4: Accessible groundwater reserves (which produce more than 70 percent of drinking water worldwide) and freshwater available in surface water; water falling as precipitation, ice and snow are rarely used.

Worksheet 2:

Exercise 1: The best overview of country data can be found in the CIA Factbook
https://www.cia.gov > World Factbook

Exercise 2: The presentation should be given as homework. Pupils should be given a week to complete it.

Worksheet 3:

Water scarcity and water shortages
A country is defined as suffering water shortages if it has fewer than 1,000 cubic metres of renewable freshwater per capita per annum at its disposal. This is the case, for instance in the Middle East and the Persian Gulf (Kuwait, the Gaza Strip and the United Arab Emirates) and in North Africa (Libya and Algeria). Saudi Arabia, for instance, had only 118 cubic metres of water per capita in 2002, making it one of the ten water-poorest countries on Earth. Yet 95% of the population of Saudi Arabia has access to drinking water, because the country is wealthy enough to offset water scarcity by drilling wells to tap groundwater aquifers, operating desalination plants which convert sea water into drinking water, and treating waste water. Ethiopia, by way of comparison, had reserves of 1,749 cubic metres water per capita in 2002, making it one of the countries that still have adequate reserves. The country lacks the infrastructure to tap and distribute the available water, however.

Exercise 1: USA, Haiti, France, Poland, Morocco, Algeria, Syria, Iraq, India, China (selection)

Exercise 2: Lack of precipitation, population growth, pollution of the environment, economic development, improper irrigation, water losses (e.g. as a result of obsolete pipes and irrigation plant), low level of public investment

Exercise 3: Current scientific knowledge points to climate change having the following impacts: There will be a further increase in global annual precipitation, especially at higher and middle latitudes and in most equatorial regions, while precipitation will drop in sub-tropical areas. There will be an increase in the intensity of precipitation, with more rain falling as relatively short but extremely strong downpours. The rising temperatures will also mean that a larger percentage of precipitation in higher latitudes will fall as rain rather than snow in winter. You will find more information in the materials on climate change provided by the online Education Service of the Federal Environment Ministry at www.bmu.de/bildungsservice.

War for water?
Water shortages are no longer a localized problem, but one that could lead to global conflict. Increasing numbers of reports like ”Water bomb ticking in the Middle East” or ”More wars about water resources feared in future” are appearing in the media. There is a vast amount of information on this topic in the Internet. Ask your pupils to use a search engine to look for items on the ”War for water”.

Worksheet 4:
Exercise 1: Elements of basic sanitation are promotion of hygiene, sanitary facilities in the home, waste water treatment.
Exercise 2:
a) true
b) false
c) false
d) true

Solar water disinfection
Swiss scientists have developed a method for disinfecting drinking water that is suitable for use in developing countries – SODIS, solar disinfection of drinking water. The method improves the microbiological quality of drinking water. The germs that cause diarrhoeal diseases are killed with UV-A radiation from the sun and by heating the water. For more information: www.sodis.ch

Information sheet 1 gives you and the class a good overall view on the topic of ”The global water situation.” Further information is available from the IHP/HWRP secretariat of the United Nations. http://ihp.bafg.de/servlet/is/8397 **> English > Information Service > Did you know?**

Worksheet 5:
Further detailed information on ”virtual water“ is to be found on information sheet 2.

Worksheet 6:
Exercise 1: Orange juice from Brazil and the USA, rice from the USA, Vietnam, Thailand, lemons from e.g. the Middle East, tea from India and Sri Lanka, soya (animal feed) from Brazil and Argentina, bananas from Colombia, Ecuador and Costa Rica, tropical fruit from African countries and Brazil, coffee from Colombia, Nicaragua etc. (selection)

Exercise 2: Nearly every supermarket has a wide range of produce originating in tropical and subtropical countries – usually available all year. In winter seasonal produce like fruit, potatoes and onions are imported from countries like Egypt (a country with water distribution problems).

Worksheet 7:
Exercise 1: sample calculation for one month, all figures are approximate!

150 g rice (450 litres), 2 kg bananas (2,000 litres), 200 g coffee (4,000 litres) or 200 g black tea (2,000 litres), 4 l orange juice (100 litres), 1,500 g meat = 1,125 g crushed soya (2,250 litres), 100 g lemons (100 litres), 150 g maize (200 litres), 500 g chocolate (1,250 litres), 1 kg tropical fruits (1,000 litres) adds up to – depending on consumption and lifestyle – some 13,000 to 15,000 litres of virtual water per month, or 160,000 to 180,000 litres per year.

Note

Experts agree that about 16,000 litres of water are expended to produce 1 kg of meat. Germany imports hardly any meat from southern countries. The sample calculation relates only to products from countries in the southern hemisphere (developing countries). Imports of soya, however, as part of animal feed, must be included in the balance. According to oral information supplied by Germany's animal feed association, the average soya content of animal feed is at least 25%, most comes from Argentina or Brazil and some from the USA. Around 3 kg of animal feed is needed to produce 1 kg of meat. That represents an average figure for domestic animals – from poultry (1:2) to pig fattening (1:3.5) and beef production (1:4).

Exercise 2: It takes up to 20,000 litres of water to produce 1 kg of cotton (see worksheet 5). A good quality T-shirt made of 100 percent cotton weighs about 250 grams. Even if you have only 10 in the cupboard, that represents 50,000 litres of virtual water. That figure does not include the water used to produce or dye etc. the T-shirt. The major cotton-producing countries are: China, USA, India, Pakistan, Brazil and Turkey.

Exercise 3: A small selection: Greater consumer awareness can be very helpful. People could buy fewer clothes, choosing better quality to last longer, opt for regional food in season, buy Fairtrade products etc. A very thought-provoking website treats some unusual aspects of the topic and can help the young people discuss the concept of "consumer awareness".

Exercise 4: Among the possibilities for reducing one's personal consumption of virtual water are: environmentally aware shopping, e.g. choosing regional products and products in season.

Note

Virtual water is not only a feature of agricultural produce! It takes 400,000 litres of virtual water to manufacture a car, for a computer 20,000 litres are used.

Have the class discuss the pros and cons of virtual water trading. Should countries with very limited supplies of water refrain from growing their own major foodstuffs, e.g. grains, and import them instead, in order to conserve resources? But how can poor countries pay for imports? There is currently heated debate on this topic in the professional community.

Use information sheet 2, "virtual water" for your discussions.

General information

www.bmu.de > English > Topics > Water
www.umweltbundesamt.de > English > Search: Water

The goal of modern learning is to shape society and one's own life in a well considered, soundly reasoned and self-determined manner working alongside others. This being so, schools must do more than teach pupils to merely react to the school's demands and to changes in later life. Teaching must enable them to acquire competencies, not only for coping with the future, but also for actively shaping the future. One fundamental aspect is therefore the acquisition of competencies that are not confined to managing and structuring everyday life in a self-determined fashion, but are also suitable for shaping life in the world of tomorrow.

So it is hardly surprising that topics like Renewable Energy Sources, Biological Diversity, Environment and Health, Water, Use of Natural Areas, or Waste and Recyclable Materials are commonly found as subjects in a modern syllabus or curriculum. These are important issues in everyday life today, and are of central importance for shaping a life worth living the world over. But is it sufficient merely to put these topics on the timetable? What kind of results do we expect as the outcome of such learning? To arrive at a clearer and more detailed picture, it makes sense to take a closer look at the competencies for shaping this future. According to a definition by F. E. Weinert, competencies are "the cognitive abilities and skills that individuals possess or can learn for solving specific problems, and the associated motivational, volitional and social readiness and abilities that enable them to use these solutions responsibly and successfully in a variety of situations." Thus competencies are primarily a matter of the ability to take action, not of abstract school knowledge. The ability to solve problems is seen here in close connection with standards, values, readiness to act and – of course – available knowledge. As the ability to take action, competencies are tied to specific objects, contents, knowledge and skills.

Competence-oriented education strategies are output-oriented, whereas conventional curricula and didactic approaches are input-oriented: the latter ask what topics the pupils should be studying. The output approach, by contrast, asks what problem-solving strategies, action concepts and abilities they should possess. Only on this basis is it possible to determine what needs to be learned. This can to some extent be made dependent on pupils' prior knowledge, motivation, local and individual everyday associations – and can thus enhance both the learner's interest in the subject and an acquisition of competence that is not confined to the mere accumulation of "dull knowledge" (Weinert). What abilities and skills, social and cultural reference points should children and adolescents possess to enable them to manage and shape their future? What knowledge should they share and have in common? These questions guide the search for teaching content when approaching the problem from the competence point of view. Looking at things from this angle, the list of possibilities is extremely long.

It is nevertheless possible to identify a few overarching educational objectives that help with the selection of what is to be learned. A study commissioned by the OECD mentions human rights, the goal of being able to practise living democracy, and the criteria for sustainable social, economic and environmental development. The pursuit of human rights, within a framework of democratic structures and in the interests of sustainable development, represents three overarching educational objectives which form guidelines for defining competencies. These statements are of no small importance. After all, the OECD is also responsible for the PISA studies; and in 2006 these surveyed pupils' competencies in the natural sciences.

The competencies that children and adolescents should possess if they are to be able to act in the interests of sustainable development are subsumed in Germany under the term Gestaltungskompetenz. Gestaltungskompetenz denotes the ability to identify problems of non-sustainable development

and apply knowledge about sustainable development. In other words, being able to draw conclusions about environmental, economic and social developments and their interdependence from analyses of the present and studies of the future, and to use them as a basis for taking, understanding and implementing decisions that permit the realisation of sustainable development processes.

This general description of Gestaltungskompetenz displays close relations to the definition of "scientific literacy" which underlies the PISA studies – including the 2006 study which investigated young peoples' competencies in the field of natural sciences. It reads as follows: "Scientific literacy is the capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity." Both competence definitions are concerned with findings, knowledge, understanding phenomena and actions, and taking decisions that affect the environment. Above and beyond this, Gestaltungskompetenz focuses specifically on problem-solving skills and the ability to take proactive and future-oriented action.

In all, Gestaltungskompetenz comprises eight individual competencies. Placing them in the context of scientific and technical findings and problems, as presented in this large package of materials, results in the following picture:

1. The competence to think in a forward-looking way, to cope with uncertainty and with forecasts, expectations and designs for the future – for example, with regard to the future use of renewable energy sources – is the individual competence to look beyond the present. The crucial factor is being able to grasp the future as something that is open and capable of being shaped with the aid of innovative technologies, and to develop various action options from current situations on the basis of this attitude. Forward-looking thinking and acting makes it possible to consider potential future developments – such as climate change – and to discuss the opportunities and risks associated with present and future developments, even if these are unexpected. At the level of learning goals, this means:

- The pupils are familiar with various methods of future research into (non-) sustainable development (e.g. energy scenarios; species reduction forecasts). They are able to use the methods in group work. They can assess and describe the strengths and weaknesses of the methods.

- The pupils are able to select the various methods of future research appropriately for problem areas of environmental change and applications of environmental technology that have not yet been dealt with in lessons.

- The pupils can reproduce the main statements of various future scenarios and forecasts, for example on climate change, especially with regard to environmental risks, poverty and non-sustainable global economic developments. They are sufficiently familiar with associated action recommendations and strategies to be able to reproduce them in their threads of argument.
- On the basis of material and information sources provided on non-sustainable or problematical developments – e.g. with regard to landscape depletion due to housing-related measures – the pupils can work together on projects to design and visualise positive scenarios of technical, social, environmental and economic change, and can present them in verbal and pictorial form both logically and on the basis of value judgements and imaginative components.

2. The competence to work on an interdisciplinary basis. Problem areas of non-sustainable development and perspectives of viable future changes can no longer be coped with by a single technical discipline or using simple action strategies. They can only be handled by cooperation between multiple technical disciplines, different cultural traditions and aesthetic, cognitive and other approaches. The development of suitable abilities is indispensable for identifying and understanding system contexts and dealing appropriately with their complexity. Such abilities are fostered by problem-oriented interlinking of natural and social sciences, innovative technical knowledge and planning strategies, and imaginative thinking and innovative access facilities. This presupposes interdisciplinary, i.e. cross-subject, learning. This leads to the following learning goals:

- The pupils can describe complex situations with the aid of integrated analytical methods from the natural and social sciences.

- With the aid of creative methods, normative criteria, personal value judgements and research-oriented learning, the pupils can work on problematical non-sustainable development situations – e.g. biodiversity reduction – in a way that permits their transformation into models of sustainable development – e.g. as illustrated by biosphere reserves.

- When presented with problem situations – e.g. the threat to fresh water from inputs of environmental toxins – the pupils can analyse them to see which technical disciplines, information sources and actors need to be consulted to permit appropriate analysis and countermeasures.

3. The competence of cosmopolitan perception, transcultural communication and cooperation. *Gestaltungskompetenz* implies the ability to grasp and localise phenomena in their worldwide context of links and interactions. This competence focuses on perceptions that broaden contexts and horizons. Because a regional or national point of view is too narrow to permit orientation in a complex global society, perception and assessment horizons need to be expanded in the direction of a global approach. For example, a Central European view of freshwater reserves and use is totally different from the viewpoint of nations and peoples in arid or semi-arid regions. In terms of learning goals, this means:

- The pupils can describe relations between global climate change, resource consumption, pollutant inputs, economic ramifications and the social situation in developing countries on the one hand, and national pollutant inputs and resource consumption on the other.

- The pupils are able to familiarise themselves independently with other cultures' views and arguments regarding individual aspects of sustainability, and to assess and use these views and arguments in their own arguments, descriptions and assessments of situations. For example, what is the significance of exporting old cars and old clothes to Africa?

- They are also able to describe, with the aid of examples, the impacts that their own actions and those of their surroundings (school; region) have on resource consumption, pollutant inputs and equitable distribution at a supra-regional level and over long periods. To this they can apply a concept for calculating flows of materials.

- The pupils are familiar with methods of presentation and treatment that reflect different interests and problems from the viewpoint of various cultures and philosophies. What arguments do

developing countries put forward when they are called upon to invest in environmental technology or to reduce pollutant emissions? In this context the pupils can undertake a conscious change of perspective, identifying and assessing important points in the perspectives of different cultures, and using them in the interests of communication and understanding.

4. **Participation competence.** The ability to take part in shaping sustainable development processes is of fundamental importance for future-oriented education. There is a growing need to take part in decisions and a growing interest in helping to shape the world in which we live – at least in our culture: Involvement in decisions and self-determination at work, in civil society (and not just when it comes to planning leisure time) – are acquiring increasing importance for an emphatically independent way of life. This implies the following abilities:

- The pupils have the ability to draw up, together with their fellow pupils, teachers and non-school partners, joint sustainability objectives – for example, with regard to species protection or the use of renewable energy. They are able to stand up publicly with others in support of their joint objectives.

- The pupils can appreciate divergent positions of individuals, groups and nations on individual aspects of sustainability – e.g. regarding the designation of nature conservation areas and the protection of certain species. Together with their fellow pupils and other actors, they are able to turn conflicts and controversies into constructive suggestions for solutions.

- On the basis of practical activities, the pupils display the ability to engage regularly with others in environmental, economic or social fields of sustainability. This may relate to reducing energy and water consumption, advocating waste avoidance, or propagating gentle tourism or ideas for sustainable homes in the future.

5. Having planning and implementation competence means being able to assess action workflows with regard to the necessary resources and their availability from a sustainability point of view, to design cooperation networks, to allow for side-effects and possible surprise results, and to cater at the planning stage for their potential occurrence. Relevant learning options discuss feedback, delayed consequences and time lags of the kind familiar from the damage to the ozone layer or inputs of environmental toxins into water, and offer a corresponding repertoire of methods. Implementation competence comprises the actual interest in pushing action beyond the intention and planning stage – for example commitment to the installation of a photovoltaic system on the roof of the school. The pupils should therefore be able to do the following:

- The pupils can use sustainability criteria to estimate the resources (e.g. heat energy, water, office materials, cleaning and polishing agents) necessary for services, production or the ongoing operation of a facility (e.g. the school) and make optimisation proposals on this basis.

- Within planning processes, the pupils are able to cope with surprise effects, uncertainties and necessary modifications by reacting appropriately to such effects and situations and readjusting the planning processes – e.g. rising consumption as a result of dwindling commitment on the part of pupils, shortfall on savings targets due to cold winters.

- In this context the pupils are familiar with the phenomena of feedback, late consequences, and delayed occurrence of problem situations. For instance, they can name examples and can describe and critically assess forms of reaction and anticipation that are practised by the economic and political world in this context. The different reactions by various nations to climate change analyses provide a number of good examples.

- The pupils are in a position to implement a project successfully on the basis of their acquired planning competence. In this respect they undertake activities by developing planning processes into action concepts and taking them to the action stage either independently or in concert with others. Saving resources, propagating new heating technologies and using environmentally friendly materials provide numerous opportunities for action here.

- They are able to present the results of their sustainable planning processes to different external groups (parents, teachers, citizens in a pedestrian zone, younger pupils) in a manner appropriate to the individual groups.

6. **Capacity for empathy, sympathy and solidarity.** All sustainability concepts set out to achieve greater equity, which always involves a balancing transfer between rich and poor, advantaged and disadvantaged, and seeks to minimise or abolish oppression. This is not just a matter of morals. It also involves the will to exploit scientific and technological potential. This in particular has frequently not been the case in the past. Many new ideas for environmentally friendly technologies are not used because of short-term economic considerations or long-established habits. The ability to stand up for greater equity and the use of innovative potentials makes it necessary to develop a certain empathy, a kind of global "togetherness". Education for sustainable development therefore aims to develop individual and collective action and communication competence in a spirit of worldwide solidarity. It provides the motivation and empowerment to find viable joint solutions to joint problems and to make a considered stand for greater equity. This starts with collecting for a solar cooker that can be used by families in semi-arid areas with little fuel wood, and continues with support for whaling rules that conserve whale populations while acknowledging the traditional whale-catching rights of indigenous peoples. This includes the following examples:

- The pupils are able to express their empathy for animal protection, species-appropriate livestock farming, conservation of endangered species and ecosystems, and biological diversity.

- They can argue in favour of local and regional measures designed to combat non-sustainable developments – for example reduction of land take for settlement purposes – and for sustainable changes in socio-economic and natural living conditions, for instance by advocating greater use of wind energy, biosphere reserves and equitable water resources management in arid and semi-arid areas of the Earth. They can express their emotional attitudes to the relevant circumstances.
- The pupils can describe, both with rational arguments and with more emotive approaches, the situation of people who live in poverty, who lack adequate medical or other care, who are oppressed, or who have little or no access to education. Thanks to their knowledge of innovative technologies and sustainable management of resources, they are able to discuss action options for improving the situation.

- They are able to argue in favour of the interests of such people with the aid of international treaties and conventions, such as the Framework Convention on Climate Change or conventions on species protection, by reference to religious or ethical standards and values, and by making use of existing scientific and artistic works.

7. **The competence to motivate themselves and others.** Getting to grips with the concept of sustainability, breathing life into it and developing viable and satisfactory everyday lifestyles requires a high degree of motivation to change oneself and encourage others to do the same. Education for sustainable development sets out to develop the motivational drive we need if we want to lead a fulfilled and responsible life even under the complex conditions of an increasingly interdependent world. Being able to motivate oneself and others means knowing about action options. In other words knowing innovative environmental technologies, resource-conserving lifestyles, nature-friendly forms of mobility and economic activity, and being able to argue in favour of their use. What does this mean when translated into learning goals?

- The pupils can cite activities and learning progress from their work on sustainability issues, such as ”Renewable Energy Sources“, ”Biological Diversity“, ”Regional Utilisation and Threats“, which motivate them to put into practice and supplement the knowledge, problem-solving strategies and action concepts they have acquired.

- The pupils can demonstrate to others their commitment, problem-solving abilities and factual knowledge in relation to sustainable development processes and the identification of non-sustainable developments by informing them, say at exhibitions and other presentations, about the use of fuel cells, wind energy, solar technology and the implications of the growing consumption of oil for energy production.

- In the course of their learning, the pupils display increasing expectations about their own effectiveness with regard to the possibility of implementing strategies for sustainable development processes. This means, for example, that after working on Renewable Energy Sources for some time they should be more convinced than before that it is possible for them to make a contribution to the ”energy revolution“.

8. **The competence to engage in detached reflection about individual and cultural models.** Identifying and critically appraising one’s own interests and wishes, localising oneself in one’s own cultural context, or actually adopting a well considered stance in the debate on global equity calls for the competence to engage in detached reflection about individual and cultural models. This is partly a question of perceiving one’s own behaviour as culturally conditioned, and partly of getting to grips with social and societal models. For example, there are socially favoured lifestyles (the ideal of a detached house out in the country; air travel to one’s annual holiday destination; a car of one’s own; solarium-tanned skin) which are problematical from the point of view of health and sustainability. What kind of abilities and skills should pupils possess in connection with this individual competence?

- The pupils are able to give a structured description and assessment of their lifestyles and their local and family environments in the light of the perspective of people and living conditions in developing countries. This can for example be done by comparing land take for housing, differences in interest in repairable equipment, or misgivings about the use of environmentally harmful chemicals. Against this background, the pupils show their ability to describe the limits of their own lifestyles and the extent to which they can be generalised.

- The pupils are able to identify and describe the intentions associated with their lifestyles in terms of their consequences for the environment and for social equity. Suitable issues for this include topics from the complex "Water Consumption", and also reflections about leisure interests, clothing fashions, interest in the protection of animals and in mobile phones free from "electromagnetic smog".

- They are able to analyse their designs for the future – for example the kind of homes they want, their ideas about mobility, use of leisure time, travel destinations – from the point of view of social equity, consideration for the freedom of action of future generations and their potential environmental impacts, and can cite action options for reducing the resulting friction between sustainability and designs for the future.

It goes without saying that it cannot be the objective of every project or every lesson to teach al these individual competencies. They define the background against which the content should be chosen and discussed and the teaching methods selected. It will of course be necessary to specify the individual competencies in more detail, particularly in relation to the material taught. This is done in the following material under the heading of "Learning Goals".

Bibliography

- OECD (Ed.), DeSeCo Strategy Paper. An Overarching Frame of References for a Coherent Assessment and Research Program on Key Competencies.
www.statistik.admin.ch/stat_ch/ber15/deseco/deseco_strategy_paper_final.pdf

To help teachers use these materials on water in schools, we can provide general information about learning goals and the way the material fits into the existing syllabus, as well as pointers on educational standards in science. This will help teachers identify the contexts in which they can use the topics, project suggestions and worksheets. The teacher handouts for the two sets contain more helpful hints.

The importance of water for future generations and thus for today's young people is entirely uncontested. Water is the source of all life. The ancient Greeks saw it as one of the four elements from which the world was made. The development of the human race always has been and continues to be linked to the existence of water. Proximity to water has always been an important factor in the location of human settlements – primarily, but not only, because water is essential for drinking. The locations of modern urban settlements too are selected such as to ensure reliable water supplies. Seas, rivers and lakes are also transport routes. They are a source of food, generate power and create a special climate. Many pupils, and indeed adults, in Europe, however, have no particular awareness of the pivotal role that water plays in our lives. All too often we forget that it is by no means "normal" that good quality drinking water is always there, on tap, available round the clock.

Facts and figures:

- Over 1 billion people, or 18% of the world's population, have no access to safe drinking water, and over 2.4 billion people do not have adequate sanitation.
- 2.2 million people in developing countries, most of them children (6,000 a day), die every year from diseases associated with lack of access to safe drinking water, inadequate sanitation and poor hygiene.
- If current trends persist, by 2025 the demand for freshwater is expected to rise by 56%. That is more than is currently available. About 70% of current demand is accounted for by agriculture, while the remainder is used by households, municipalities and industry.

From: Annual report 2003 from the Commission to the Council and the European Parliament on the EC development policy and the implementation of external assistance in 2002 (available online at: http://www.pedz.uni-mannheim.de/daten/edz-h/az/03/com_2003_0527_en.pdf)

Learning goals (in brief)

One goal of these materials is to expand pupils' knowledge and understanding of how vital and valuable water is as a resource. Equally they are to be enabled to assess the problems involved in securing water resources. In Set 1 "Living Rivers", pupils should initially recognise the importance of water for human beings, and understand the complexity of providing safe drinking water. Set 2 takes them beyond the local dimension to introduce the global perspective. Under the motto "Lifestyle and the Global Water Crisis", pupils learn that safe drinking water is often in short supply in many countries of the Earth.

Alongside pupils' own water consumption, the focus is on the innovative approach involving "virtual water"*. Pupils should take a critical look at their own water consumption (for instance calculate their own monthly consumption of virtual water), which should then encourage them to think about alternatives (production of a guide to the global water crisis and consumer behaviour).

Pupils should be encouraged to work in pairs or in groups to help them deal in depth with this complex and complicated topic. You should provide for regular feedback to focus results and to ensure a discussion of the different positions which are bound to emerge within the class. As pupils are required to deal with views that are not their own, their abilities to play a cooperative role in socially heterogeneous groups will be strengthened.

Points of contact with the syllabus (in brief)

Water as a topic is firmly established in the syllabus for junior secondary level in several forms. It is found in particular in biology, where it is the focus of several units from "Water – a symbiosis" to "Water – a resource in short supply". The key topics of the syllabuses are water as a ecosystem, water pollution, water purification, water protection and water as a finite resource.

Set 1 can be used in particular for pupils age 13 to 15, in chemistry, geography and biology. The importance of water for our lives is underlined in topics such as "Water – the basis for life", "Water – its importance for life and the environment", and "Water for industrialised societies". Anthropogenic influence on water resources and the resulting ecological conflicts also feature on the syllabus (e.g. under water resources management, flooding). Set 1 thus links up well to the syllabuses which do not merely admonish pupils but which aim to encourage them to realise what they can do to change their own consumption patterns. "The goal should not be to identify and list environmental damage and destruction, but to get pupils to examine their own behaviour and adopt environmentally responsible behaviour patterns." (Syllabus for biology for junior secondary level, Federal State of Schleswig-Holstein, p.94).

The educational materials contained in Set 2 "Lifestyle and the Global Water Crisis" also link up best with the syllabus for pupils age 13 to 15 in biology and geography. Global water consumption and the results of water shortages are tackled in the syllabuses with topics such as national water consumption and global water crisis and "Water – a scarce commodity". Here too, pupils should take a long, hard, critical look at their own lifestyles.

"All topics which help us reinforce or encourage behaviour patterns involving responsible interaction with energy, the air, water, soil, the countryside, and flora and fauna can be used." (syllabus for biology for junior secondary level, Federal State of Schleswig-Holstein, p. 94) You will find more detailed information on link-ups to the syllabus under "Information for teachers", where each of the two sets is dealt with separately.

* Virtual water is a fairly new term in hydrology, where it is used to mean all the water used to produce a given product.

WHAT DO SYLLABUSES AND SCIENTIFIC EDUCATION STANDARDS FOR INTERMEDIATE SCHOOL CERTIFICATES SAY ABOUT "WATER"?

The scientific education standards of the KMK (standing conference of the ministers of education of the federal German states) make clear references to "Water", especially in Biology. The topic of "Water" is discussed in connection with the teaching of knowledge about ecosystems, and especially in relation to water uptake by plants. Examples of the use of water by human beings are also quoted when it comes to acquiring standardised competencies in Biology.

The standards for Chemistry make technical knowledge necessary when describing substance cycles in nature and technology. All natural sciences automatically show close connections with the topic of "Water" in the fields of knowledge discovery, communication and assessment. Accordingly, the material presented here builds on observation, systematisation, modelling, hypothesis formation, experimentation and the postulation of simple theories, and also on the acquisition of competencies designed to permit subject- and audience-specific communication and assessment of human use of water on the basis of scientific knowledge.

A special approach is necessary for Geography. The education standards for intermediate-level Geography drawn up by the DGG (German Society for Geography) provide many references to the subject of "Water". In general, the standards provide for acquisition of technical knowledge about the function and course of natural geographical processes. This can be done by working on bodies of water and ecosystems.

Pupils should also be able to explain "the impacts of area use and management (e.g. land clearance, water pollution, [...] water shortage)" and "explain in systemic terms the impacts of area use and management (e.g. [...] resource conflicts, marine pollution)".

Pupils should furthermore be able to "explain possible meaningful measures of an environmental, social and/or economic character for protecting areas [...] ". To this must be added skills in using spatial organisation systems, maps, geographical information sources, etc., which are to be taught in Geography and which are repeatedly available in this package of materials.

In the intermediate-level education standards for the Natural Sciences and Geography it is possible to identify seven key topics for the complex of "Water":

- Ecosystem Water
- Importance of water in physical geography
- Importance of water in human geography
- Use of water in the (agricultural) economy and in the household
- Water treatment
- Environmental pollution and destruction in relation to bodies of water
- Water conservation

Teaching pupils to know and assess the wide-ranging significance of the physical and human geography functions of water is the principal aim that this material sets out to achieve. The first task here is to explain, starting from the use of (tap) water that we take for granted, how complex the processes of water supply and wastewater disposal are, and also to understand how drinking water is produced and in what quality and quantity it is available (e.g. as surface water and groundwater).

However, the function of water, lakes and rivers is not confined to "providing" water as an indispensable food. Rivers, lakes and seas are transport routes and a focus of human settlement. They are of great climatic importance and have always been a magnet for economic uses (fisheries, agriculture etc.). Human intervention such as straightening, pollutant inputs etc. repeatedly prove to be factors which endanger and damage complex biocenoses that develop in and near water-dominated biotopes. For this reason it is also important, especially from a sustainability point of view, to deal with measures for renaturing rectified watercourses, sustainable use of water bodies and water as a resource, and also with flooding and other problems. This is possible with the material in Set 1. From age 12 to 14 onwards, the syllabuses for Geography and Biology and for interdisciplinary teaching display very close connections with this topic area.

In Set 2 the focus is on global aspects. Here there are close links with Geography from age 12 to 14 onwards. Knowing about and being able to assess the worldwide occurrence of freshwater and drinking water, and the various ways and quantities in which it is used in the household or in the industrial and agricultural sectors in individual countries around the world is of great importance for understanding the differences between industrialised and developing countries. Repeated reference to the pupils' own everyday situation (personal water consumption) demonstrates the great regional and local variations that exist worldwide when it comes to access to drinking water and basic sanitation. Moreover, from the perspective of viable future development it is essential to take a close look at future needs for fresh water, and especially drinking water, since factors such as population growth in Asia and parts of America and Africa, urban agglomerations, intensified agriculture, and industrialisation processes are creating an ever-increasing demand for fresh water of specific quality. Water shortages and water management are closely connected.

A special section is devoted to the topic of "virtual water". Discussion of this topic is of great importance from the point of view of sustainable consumption. How many people are aware how much water is needed to produce a kilo of rice or a litre of orange juice? Drawing attention to the water that has gone into products (i.e. the water necessary for their production) makes it clear that our daily consumption of drinking water usually accounts for no more than a small proportion of our daily water consumption. And when pupils know that a kilogram of (early) potatoes imported from Egypt needed 1,000 litres of water, which is very scarce there, to grow into an exportable product, they can judge what contribution they personally are making to water shortages in other countries.

The intermediate-level standards of the KMK for Chemistry, Biology and Physics are binding for all federal German states. Since they serve as the rules for future measurement of your pupils' performance, the following remarks set out to clarify how the material on "Water" is related to the educational standards. The intermediate-level KMK standards for "Biology" do not explicitly mention the topic of "Water". This is due to the general approach used in the wording of educational standards: they formulate competencies.

The content from which these can be acquired is not explicitly defined. However, the examples that illustrate what content can be used to achieve these competencies include numerous pointers to "Water", especially in Biology. In our context this is particularly true of the pointers to the importance of ecosystems: For example, pupils should learn to analyse the functions of organisms in the ecosystem, portray the substance cycle and energy flows in an ecosystem, outline the interactions between living beings and other spheres of the Earth, and describe the changes in an ecosystem over time. In the field of knowledge discovery, moreover, the pupils should be able to explain dynamic processes in ecosystems with the aid of model concepts and assess the information value of a model.

In this context, mention must also be made of the competence areas Communication and Assessment. The pupils should describe and explain originals or faithful illustrations with the aid of drawings or idealised pictures, and be able to present data on measurable parameters of systems. They should also learn to assess various measures and behaviour patterns relating to their own health care and social responsibility, and the impacts of human encroachment on an ecosystem. In the context of sustainability, the education standards for Biology also stipulate that pupils are to learn to assess influences on global cycles and material flows from the point of view of sustainable development, and discuss action options for environmentally sound and nature-friendly participation in the interests of sustainability.

The intermediate-level education standards for Physics do not display very strong links with the package of material. In the competence area ”Assessment“, however, the pupils are to compare and assess ”alternative technical solutions, taking account of physical, economic, social and environmental aspects“. For example, this applies to the question of the consequences of changes in the flow rate of straightened rivers (Set 1, Worksheet 3). In this context too, pupils acquire technical knowledge, and physical knowledge discovery processes are discussed (perceive, classify, explain, examine, construct models).

The education standards for Chemistry in the competence area ”technical knowledge“ play a role in that the pupils should learn to describe ”examples of substance cycles in nature and technology as a system of chemical reactions“. They should also grasp ”problems in real situations“, ”identify conflicts of interests“ (e.g. relating to fertiliser and pesticide inputs into water), consider ”possible solutions“ and discuss ”their consequences“.

WHAT COMPETENCES SHOULD PUPILS ACQUIRE AS THEY TACKLE THE TOPIC AREA "WATER"?

- Pupils become familiar with complex sets of circumstances relating to "Living Rivers" (for instance river courses as areas for human settlements and economic activities, rivers as food producers) and "The Global Water Crisis" (for instance, global water supplies, virtual water) on an interdisciplinary basis. They can recognise and describe the problems involved (for instance in Set 1: mutual influences between human beings and rivers, ecological conflicts; Set 2: water as a scarce resource, the consequences of virtual water imports), and can draw conclusions and produce their own assessments on the basis of the knowledge they have acquired.

- By adopting various perspectives (of the global water situation), pupils learn to present the various points of view relating to (non-)sustainable developments.

- On the basis of the information thus gained, pupils can assess different (non-sustainable) imperatives and patterns of action with respect to the global water crisis, and can thus make decisions affecting their own everyday activities (i.e. change their consumption patterns). In this context they can name and assess the approaches and concepts used in sustainable water resources management.

- Pupils are familiar with methods of forecasting appropriate to their own lives (scenario techniques) used to analyse the problems associated with future water supplies and the consequences thereof, and to anticipate possible sustainable developments in this field. Pupils should discuss and analyse their different points of view in groups and as a class and deal democratically with controversies arising. They should be enabled to deal constructively with differences of opinion and conflicts.

- They are able to present the results of their work and their findings with respect to the global water crisis to different external groups (for instance pupils from different classes, parents, the school website) in a way appropriate for the respective target group. In this context they should describe their individual and shared learning paths and outline how these can be used for further learning.

- Pupils identify and assess the background to, and the form and impacts of their own lifestyle and that of other people and societies on the living and working situation of other individuals and on the biosphere in terms of water.

- They can describe ways of life which ensure and encourage sustainable consumption of water, as well as the environmentally and socially sound utilisation of the resource.

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