Federal Ministry for the
Environment, Nature Conservation
and Nuclear Safety

Water · Prosperity · Change

Protecting our water resources creates a secure foundation for life, biodiversity and sustainability

IMPRINT

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p. 71: Werner Rohrmoser/BMU

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CONTENTS

FOREWORD

Dear Reader

Water is the basis of all life and a vital asset. We use water to sustain ourselves and in our daily hygiene. We are aware of water as the habitat of many plant and animal species, whether it be in seas, lakes, rivers or wetlands, but we also experience water in our leisure activities – in and beside it. Moreover, water is an important economic factor as a source of energy, a medium for transport and a resource. Adequate access to clean water is of fundamental importance for our health and sustenance.

Thus water is one of our key resources, and we must afford it special protection. That also includes the ecosystems which are essential for the continued availability of water. Only by doing this can we justifiably claim to manage our waters and thus our water resources sustainably.

What is the aim of our sustainable water policy?

There are three essential aims at its heart. The first is the long-term protection of water as habitat and as the central element of ecosystems. The second aim is to safeguard water in its various facets as a resource for present and future generations, including the aspects of health, food, production and locational advantages. The third aim is to devise options for environmentally sustainable economic and social development.

Sustainable water policy is not just a national responsibility. For billions of people on earth – even in parts of Europe – a guaranteed water supply and sewage disposal system can still only be dreamt of. Inadequate access to a secure water supply and the absence of sanitation and adequate sewage treatment are still the main causes of poverty, poor nutrition

and disease in many places. Germany is addressing this in the context of development cooperation as one of the main donors in the water sector. However, these efforts alone will not suffice. The international community must successfully establish clear ground rules to prevent the over-exploitation of water resources in developing countries under pressure from international competition.

A sustainable water policy needs support in many quarters, because all water use leaves its mark. Substance inputs to water bodies, water abstraction and construction operations alter the qualitative and quantitative state of the aquatic environment, including groundwater. This is why the various uses must be reconciled with one another and with water resources protection: to have ecologically intact watercourses, clean groundwater and pollution-free seas and coasts.

This brochure examines all facets of the use of water and water bodies and shows the routes to the protection of the aquatic environment: routes that have already been travelled, and those that lie ahead of us. For the routes that lie ahead we need broad acceptance. I will be delighted if, after reading this publication, you also support the protection of our water bodies.

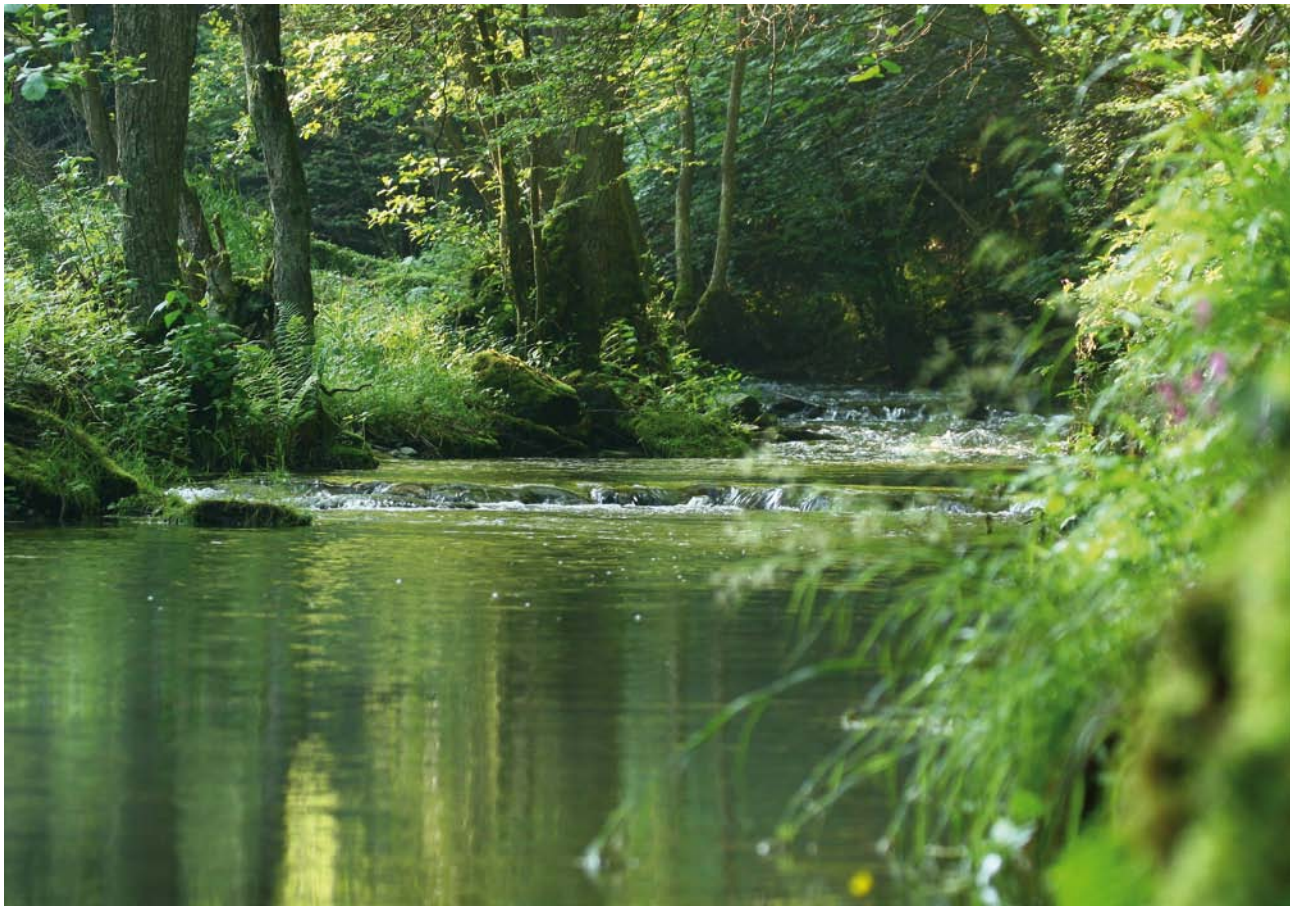
Dr. Norbert Röttgen
Federal Minister for the Environment,
Nature Conservation and Nuclear Safety

CHAPTER 1: WATER IS LIFE

Without water there is no life – that is a truism and at the same time an important scientific fact: on other planets the first thing scientists look for are signs of water. Life can only evolve where there is water. On earth, too, we owe our existence to water, although at first glance the conditions do not look all that favourable: the largest amount by far is undrinkable salt water. Freshwater accounts for only three percent, of which two-thirds is locked up as ice in the polar icecaps, glaciers and permafrost soils. Well above 99 percent of the liquid freshwater flows as more or less deep groundwater in the earth. Only the tiny remaining fraction is directly available in lakes, marshes and rivers.

Water is one of the most important natural resources. In its Basic Law the Federal Republic of Germany has made the protection of the natural foundations of life and thus of our water resources a constitutional goal.

Fortunately, unlike other natural resources such as oil, coal and metal ores, water is not used up and thus lost. The total amount of water on earth neither increases nor decreases. Whatever we do with water, it will circulate in an endless cycle. Water evaporates from the oceans and land, condenses in the atmosphere to form rain or ice and falls to earth again. Rain permeates the soil, fills the aquifers or collects in streams and rivers, thus returning to the sea. Similarly, the water used by man is treated, re-enters the cycle and can be used and contaminated again.



Near-natural rivers and their alluvial meadows are home to a wide range of animal and plant species

Protecting the aquatic environment not only safeguards the survival of plants and animals. The protection of water resources is a prerequisite for clean drinking water and safe water for bathing, and a basis for sustainable use by shipping, industry, tourism and agriculture. Last but not least, water protection is effective climate change mitigation, because global warming alters the water balance and presents politicians and society with major challenges.

Germany does not easily lend itself to water protection, however: it is a densely populated country with large cities and industrial developments on the banks of its rivers. We have an industry of over 130,000 businesses which use and pollute large amounts of water every day. Farming uses around half the land surface for crops and livestock, and releases not only polluted water into the environment, but also pesticides and fertilisers. In Germany we have over 7300 kilometres of waterways, including the Rhine, the busiest river in Europe. Our energy generation consumes 25 billion cubic metres of cooling water annually, 7400 hydroelectric power plants generate over 20 terawatt hours of electricity. In other words, almost no other country uses its water bodies as intensively as we do.

Constantly improving regulations in water legislation and the dense network of modern treatment works mean that the pollution of our rivers and lakes has diminished. However, maintaining the high quality is not easy, and it is an ongoing task. So the discharges of heavy metals, industrial pollutants and phosphorus has fallen significantly in the last twenty years, and treatment works and industry now pump far fewer substances into the aquatic environment than they used to.

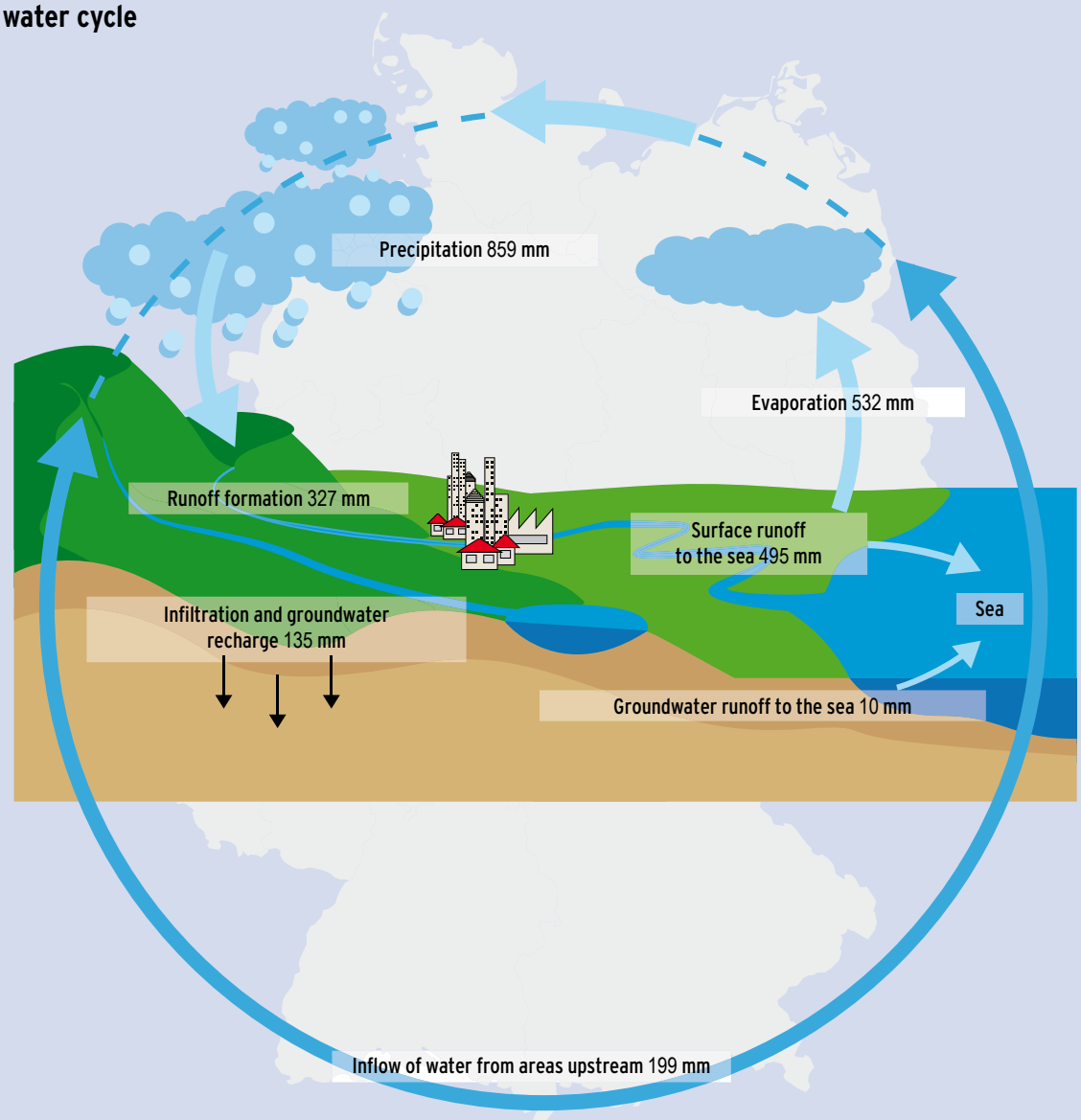
Germany is not a country short of water; the annual precipitation here is 850 millimetres. Usable water amounts to 188 billion cubic metres. So we don't have to save water as many nations in the world do, but we must look after it.

Germany is a country rich in water

At the same time the diffuse inputs from agriculture, for example, remain high and have fallen only slightly in past decades. Microsubstances, or trace substances, which have been increasingly detected in the aquatic environment only in the last few years, are presenting new problems; they are extremely difficult to remove via conventional sewage works or treatment plants. These include drug residues as well as trace substances from industry.

We take three quarters of our drinking water from groundwater. Germany has substantial groundwater reserves and around 17,000 water protection zones in which only limited economic activity is allowed, thus contributing to limiting substance inputs. Nevertheless many groundwater resources are contaminated with chemicals, sometimes from industrial substances and sometimes from agricultural discharges. Protecting groundwater from pollutants is therefore one of the main responsibilities of water resources management.

Our water cycle



Total annual precipitation in Germany is 859 mm. Rivers are bringing an additional 327 mm into the country. 135 mm reach the groundwater. The major share evaporates or goes into the sea.

Source: German Meteorological Service, edited by the Federal Institute of Hydrology

Anyone who opens an old book of photographs will see immediately that there is not one river, stream, or lake that is still in its original state. In the past water bodies were straightened, widened, shortened and cut mainly for shipping, industry and energy generation. These radical morphological alterations destroyed many natural habitats. That is why the revitalisation of our waters is a major water protection task for the coming years.

Nowadays the idea that water bodies are not just there for economic benefit, but are also an indispensable habitat for animals and plants, is gaining increasing acceptance. Floodplains and wetlands act as natural mechanisms for managing flooding and are biodiversity hotspots. The restoration of continuity is right at the top of water conservationists' to do list. This is because in Germany today not one of the larger rivers is passable for migratory fish along its

For many years water resources management has concentrated mainly on exploiting the aquatic environment. Today the conservation of nature and the environment has become more important again.

entire length, as several hundred weirs and barrages cut off the organisms' path. In 2009 important provisions on minimum water flow, continuity and environmentally sustainable use of hydropower were enshrined in the Federal Water Act. Through this the protection of fish is now a nationally regulated precondition for the use of hydropower.

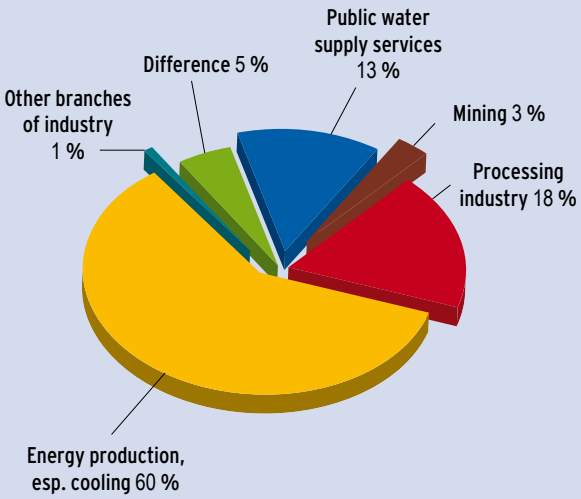
One of the main aims of water resources management is to return water bodies altered by humans to their natural state. This is no easy task, as use and conservation interests clash at water bodies everywhere. Clearly, no one wants or is able to prohibit shipping or electricity generation by hydropower plants. But in future a lot will depend on finding a balance between the conflicting interests of economy and ecology, and by doing that permit a more sustainable use of our water resources.

Many plant and animal species are directly dependent on water. That is why Germany has for years been committed to the expansion of Natura 2000, the Europe-wide network of sites protected under the EU Habitats and Birds Directives. It now consists of more than 25,000 sites, which together make up around 20 percent of the total land area of the EU – an area about the size of France. 5,000 of these sites lie inside Germany, with the result that today around 15 percent of our land is protected, much of it for the benefit of water-dependent species and habitats.

One of the new challenges for managing water bodies in future will be to prepare for the possible consequences of climate change, since this alters the water balance and therefore our everyday use of water. No one can halt climate change, so in future the main question is how we can prepare for and adapt to changes in precipitation, longer periods of drought, increased risk of flooding and regional water shortages.

Even if no one gives it a thought while showering, washing or cooking each day, water is a precious liquid. Water is not a commercial product like any other but, rather, a heritage which must be protected, defended and treated as such – so says the EU in its Water Framework Directive, which will in future shape the water policy of member states to a large extent. This premise corresponds to the German philosophy, according to which the supply of water is based on cooperation, sustainability and precaution. The protection of water resources is at the heart of all future economic development – both in Germany and elsewhere in the world. Because without water we would not exist.

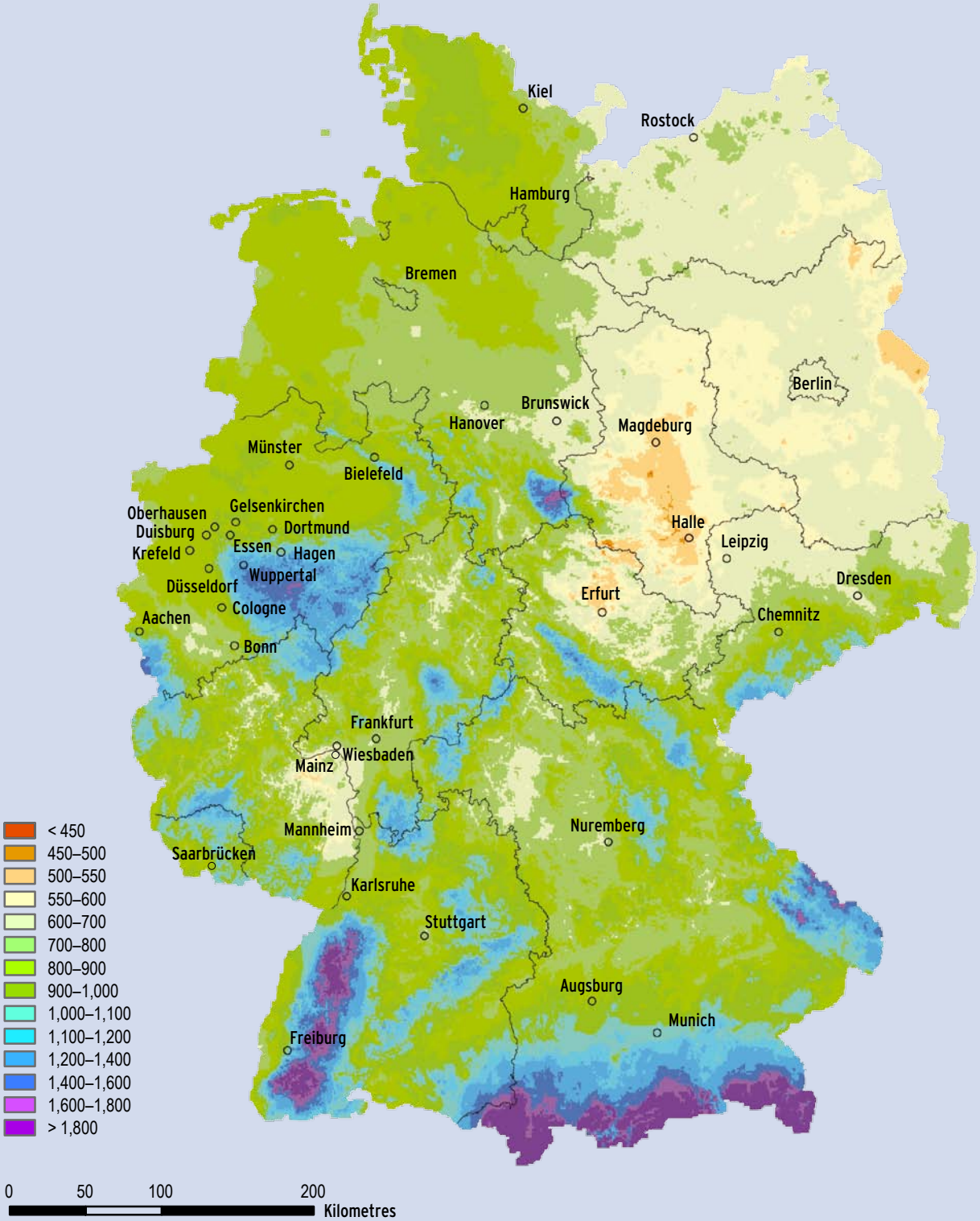
Water use in Germany 2007



Source: Federal Statistical Office

Precipitation in Germany

Hydrological atlas of Germany – Corrected average annual precipitation



Source: German Meteorological Service

Young salmon in a fish farm. Soon, they will be swimming in rivers before returning as adult fish to breed.

Protecting the aquatic environment needs staying power. The restoration of shorelines, floodplains and wetlands can only be achieved over decades. Since as long ago as the 1970s the Federal Government and the *Länder* have been promoting the conservation and restoration of nationally important and representative natural spaces. The aquatic environment almost always has a key role in these – in the form of wetlands, floodplains, mires, backwaters, lakes or alluvial land.

For example, in the **Donauried** to the north of Augsburg there is one of the largest contiguous alluvial forest complexes in Germany, extending over a length of 87 kilometres. It is home to more than 500 species that are threatened with extinction. By 2019 alluvial forests and alluvial biotopes are to be brought up to an 'exemplary conservation status'. The measures necessary – the creation of new floodplains, restoration of the banks of the Danube and ecological forest management – are being funded with ten million euros from the Federal Government and *Länder*.

There is also a unique project to the northwest of the town of Brandenburg. Here the **Untere Havelniederung** (the lower Havel alluvial plain) forms the largest area of wetland in Central Europe, supporting around 1,000 threatened or protected species. By 2021 the Havel is to be restored at a cost of around 23 million euros – by removing bank revetments, reconnecting backwaters, activating floodways, levelling dykes and creating alluvial and riverside woodland. The restoration of a federal waterway on this scale is without precedent in Germany and of supraregional importance.

Interview with Dr. Fritz Holzwarth,
Deputy Director-General for Water Management
at the Federal Environment Ministry

"Water is the most important issue for mankind"

Dr. Holzwarth, you were in Stockholm recently, where thousands of experts meet every year for World Water Week. What message have you brought back?

Water is the key requirement for sustainable development, and therefore one of the most important issues for the future of mankind. Without water there is no food, which means hunger. Without water there can be no energy and no manufacture of goods. In Stockholm we focussed particularly on the problem that more and more people in developing countries and emerging economies are living in megacities. However, these often have no clean drinking water and no regulated sewage disposal. This makes people ill and economic development impossible. If we don't pay more attention to water we will have even more social and economic problems in the future.

In 2000 the United Nations set out in the Millennium Goals that the number of people without access to clean drinking water and sanitation should have halved by 2015. The world is far from achieving this.

There have definitely been successes since then, such as in the Asiatic region. What was perhaps not considered in 2000 was that the Millennium Goals mean that, based purely on figures, several hundred thousand people would have to be connected to a water supply and sewerage system every day of the year. That can't be done, as we now know. But only by having ambitious aims do you get ambitious programmes. Without the millennium resolutions we wouldn't have got this far.

The Stockholm Statement of August 2011 states that by 2020 agricultural irrigation should become 20 percent more efficient, cooling of power plants should use 20 percent less water, and water should be recycled more and polluted less. How can that be achieved?

The percentages are not the key point. What matters is that the figures clearly show how much potential there still is in water resources management. In other words, we are still wasting far too much water, and that's true the world over. The Stockholm Statement also makes it clear that the possibilities lie mainly in sectors such as agriculture and the energy industry.

What is Germany doing to ease the world's major water problems?

Germany is one of the three largest donors in the world for development cooperation in the water sector. But technology alone can't improve things at all if there are no corresponding policy structures alongside. The water crisis is essentially a crisis in governance, that is to say, a lack of awareness of the problem and the correct way to manage it. So German development cooperation also aims to improve governance structures by advising governments and authorities. This serves to help people help themselves.

In comparison we in Germany live in the lap of luxury. We have enough water wherever and whenever we need it and enough clean water – so is everything in the garden lovely?

Even here there are still things to be done. We still have diffuse inputs of pollutants into our water bodies, for example, nitrates and pesticides from agriculture. Because we are an ageing society, people need more and more medicines and these get into wastewater via excretions. These micropollutants cannot be removed at the sewage treatment works. So we will have to take a thorough look at this in the future.

Are all the countries in Europe as sensitive to water issues?

The problems in Europe vary widely. Some countries are suffering water shortages while others are faced with flooding and heavy rains; some are having to deal with both of these. Although in the past we reduced the chemical pollution of water bodies with treatment plants, we didn't pay much attention to the morphology of our rivers. There are hardly any water bodies left with their natural course, which has led to a depletion of habitats for animals and plants and to the intensification of flooding. Furthermore I can see deficiencies in the protection of groundwater. This is an extremely important and yet invisible resource, so it is often overlooked. That has to change, because impurities that get into groundwater are far more difficult to remove than they are from rivers and lakes.

The protection of waters often only succeeds through international efforts – is Germany an important driving force in this?

Of all the countries in the world Germany is the one with the most transboundary rivers. So we have considerable experience of cooperating over water protection, for example with the Danube and the Rhine. We can bring this experience to international discussions such as those about the Nile or the Mekong.

The Federal Environment Ministry is hosting an international water conference in Bonn in November 2011. What is the purpose of this?

In June 2012 the UN follow-up conference to the Earth Summit of 1992 is taking place in Rio de Janeiro. Germany wants the issue of water to be at the top of the agenda at this 'Rio+20' conference. The message from the event in Bonn is this: Water is the elixir of life for human development. In the past water matters were much too often discussed and treated as a separate sector. Nobody gave much thought to the fact that water has vital connections to other areas such as agriculture, industry, energy generation and urban development. Managing the water crisis opens the door to sustainable development. That's what we are working towards.

Can ordinary individuals actually do anything to alleviate the problems with water?

Many people may smile when they read the hotel notice about re-using towels several times. But with every wash load and every dishwasher water is not only used but also polluted. We should also think more often about the good condition our rivers and lakes are in and about the fact that unlimited clean water comes out of the tap 24 hours a day. Billions of people on this earth can only dream of that luxury – on our next holiday in hot southern climes we would do well to remember that.

CHAPTER 2: WATER FOR DRINKING

The drinking water in Germany is one of the cleanest and best in the world. This is mainly owing to a good water supply infrastructure, which conveys the drinking water from A to B almost without loss. However, water inspections by health agencies and water suppliers also make a significant contribution.

Averaged out across the whole of Germany, the consumption per person is 123 litres a day. However, very little of it is actually for drinking – far more water is used for showering, bathing and washing (around 60 litres) and to flush the toilet (around 34 litres). Only four to six litres are taken for cooking and drinking.

Water supply and distribution is a core responsibility of local public services in Germany. To guarantee the high quality of the water, the companies spend substantial sums every year. According to figures from the German Association of Energy and Water Industries (BDEW), over two billion euros were invested in 2010 alone, mainly in treatment plants and mains systems.

Clean drinking water does not fall from heaven – it requires a complex technical procedure to produce clean, safe drinking water from raw water. In Germany there are basically two different types of raw water: groundwater and spring water (including river bank filtrate), and surface water, meaning water from rivers, lakes and reservoirs. The use of the two types varies widely between regions. The city states of Bremen and Berlin, for example, draw their water almost exclusively from groundwater sources, while *Länder* with large land areas such as Baden-Württemberg can rely on springs and water from lakes (e.g. via the Lake Constance water supply service). From a countrywide point of view groundwater is our main water source: most *Länder* pump three quarters of their drinking water out of the ground.

Around 18,000 waterworks across Germany process raw water through a variety of stages. In 2010 around four cubic kilometres of drinking water were produced for private households – that equates to approximately a twelfth of the volume of water in Lake Constance.

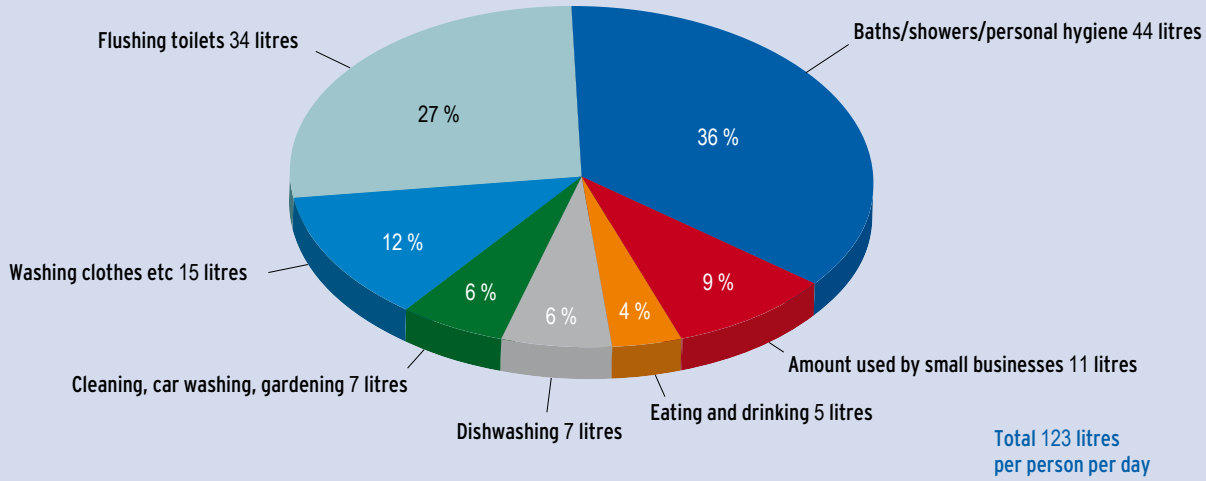
Purification of drinking water involves the removal of bacteria, viruses and harmful chemical substances such as iron compounds and nitrates from the water. The waterworks use various technical processes for this. Solid matter and visible impurities are removed via the process of filtration through gravel. Activated carbon filters absorb harmful hydrocarbons and other dissolved organic compounds. The oxidation procedure is also widely used: dissolved iron and manganese compounds are precipitated by reacting with oxygen and removed in aeration tanks.

The legal basis for clean water is the Drinking Water Ordinance. It first entered into force in 1976 and specifies limits for substances including nitrate, ammonium, iron, manganese, sulphate and nitrite. In addition the pH value, the electrical conductivity and the clarity of the water are addressed. Since the most recent amendment at the end of 2010 the Ordinance has included new provisions on contamination with legionella, uranium and micro-organisms. These new additions mean greater protection for the consumer; for example, the requirement to minimise micro-organisms in drinking water reduces the risk of infectious diseases. Traces of uranium are also hazardous to health, so a limit of 0.01 milligrams per litre has been introduced for this substance.

The Drinking Water Ordinance determines how clean the treated water must be. It is regarded as one of the most stringent regulations for drinking water in the world. The supreme objective of the Ordinance is to provide water that is safe for human health.

Drinking water use in the home 2010

Average values refer to the water supplied to households and small businesses



Source: BDEW German Association of Energy and Water Industries

The Drinking Water Ordinance represents the basis for inspections by water suppliers and health agencies. Clean drinking water requires constant monitoring and inspection of the waterworks, as well as the technical equipment used in them. There are many aspects to the monitoring programme, ranging from conserving resources and monitoring the technology and the mains system to quality controls of the water-works and water from the tap. As part of this the health agencies take random samples from the mains water supply and examine them thoroughly. This acts as a supplementary check on the monitoring carried out by the waterworks.

However, whether the water from the tap is really clean does not depend only on the waterworks and the treatment technology. Another important factor is often the quality of domestic installations. For example, many water pipes in older buildings in the east and north of Germany are still made of lead, which can result in higher concentrations of heavy metals in drinking water.

Even without lead pipe work domestic installations can be a source of contamination: while carrying out an evaluation of health agency readings, microbiologists in Duisburg and Bonn found a relatively high number of harmful germs in domestic installations. What few homeowners know is that the supply company only guarantees safe water quality as far as the point of entry to the house. The householder is responsible for the installation inside the building.

If plumbing is not used regularly, pipes are too wide or water softeners badly maintained, biofilms can form in pipe walls, and on seals and fittings. Micro-organisms survive particularly well in these biofilms, because they have ideal conditions for growth there. The researchers established that the risk from coliform bacteria and legionella, especially to children, the elderly and people with impaired immune systems should not be underestimated. However, the risk can be prevented through relatively simple measures (see box).

How do I prevent germ contamination?

Contamination of domestic water pipes can be prevented by taking these simple precautions: :

- Make sure you run the water through the pipes in your domestic plumbing at least every four weeks
- Only use the cold tap for drinking water
- Clean the water filter at least every two months
- Only have drinking water systems serviced by professionals
- When buying items such as building components and pipes look for the DVGW industry association seal of approval.

Since 1990 water consumption has been falling in Germany. Twenty years ago the average German still used 145 litres per day; this has now dropped by more than 20 litres. There are a number of reasons for this. Firstly, we have learnt to use water sparingly. Secondly, new installations now have water-saving fittings. Last but not least, demographic change is a major factor: the number of inhabitants is falling in many regions, and in any case older people use less water.

Saving water makes sense. However, there is also a real downside. Lower water consumption means an increased maintenance programme for the mains system, on account of the reduced flow volumes. The risk of germs forming increases, as the drinking water sits in the pipes longer. The demographic change is mainly leading to population decline in the east of Germany. One of the main responsibilities for the water suppliers in future will be dealing with this development.

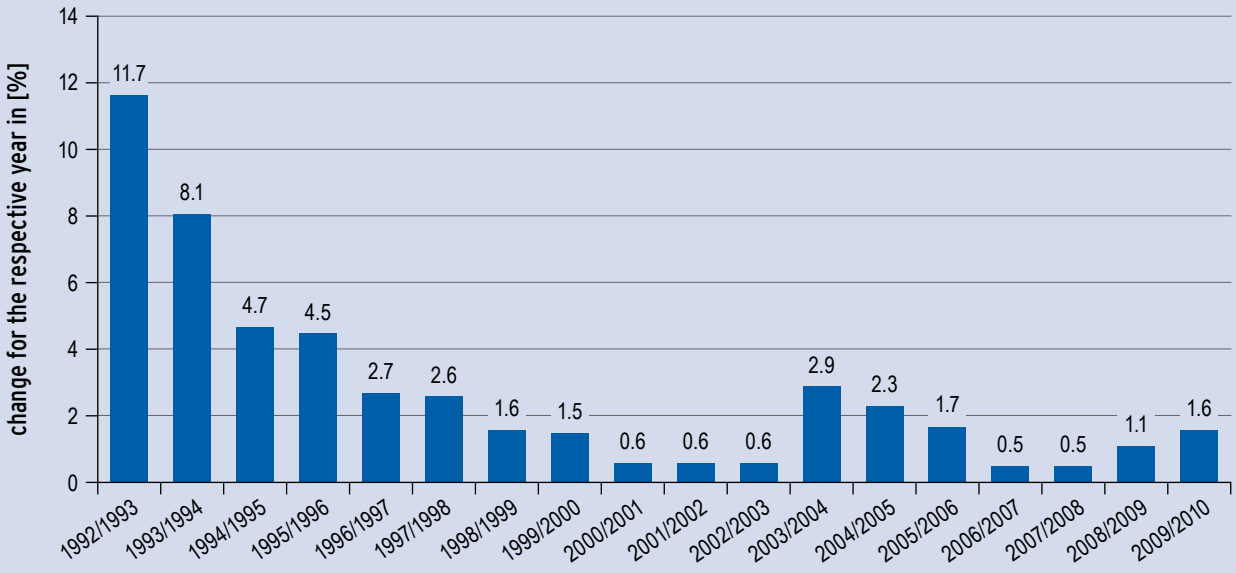
A lot of people may complain about constantly rising charges but, according to a study by the Bundesverband der deutschen Gas- und Wasserwirtschaft (Federal Association of German Gas and Water Industries), each German citizen spends an average of 24 cents a day on drinking water, which – excluding sewage charges – adds up to approximately 86 euros. For comparison, an average household pays at least ten times that for electricity. On the whole 86 euros is an absolutely justifiable amount, when we are talking about the most important resource we know for drinking and meeting our everyday needs!

Clean water is affordable: on average German consumers pay 86 euros a year for their drinking water.

But there is no such thing as a standard charge; if one compares the water prices in different regions and towns, clear differences become apparent. In 2010 a cubic metre of drinking water cost 1.58 euros in Munich, 2.24 euros in Berlin and a massive 2.46 euros in Halle (Saale). There are a number of reasons for the wide variation in prices: water mains of different ages need different amounts of maintenance, which will cost different amounts of money. Production and treatment costs vary depending on the quality of the raw water and the soil conditions.

In recent years there has been little change in the average price of drinking water in Germany; at the moment it is around 1.90 euros per cubic metre. Mains systems account for the lion's share of this, with 57 percent of the costs, while only about 7 percent is spent on raw water abstraction.

Rates of increase for drinking water price



Source: BDEW German Association of Energy and Water Industries; BDEW – Water tariff statistics

Interview with Ulrich Peterwitz, geologist and Managing Director of the Arbeitsgemeinschaft der Wasserwerke an der Ruhr (Ruhr waterworks consortium)

"There will always be new problem substances"

Mr. Peterwitz, would you drink water straight from the Ruhr?

No, there are too many germs in the water. Nor is swimming allowed in the Ruhr, for the same reason.

For very many years the Ruhr was the sewer for the mining and heavy industries in the Ruhr District. What condition is it in today?

Much better. There are few coal and steel operations left in the Ruhr District, and even if the rest were still there, the inputs of previous decades would no longer be permitted now. Besides this, the Ruhr association has done an enormous amount for wastewater treatment.

How do the water suppliers get clean drinking water from the Ruhr?

The 32 waterworks on the Ruhr supply more than four million people with what is known as enriched groundwater. The process is based on a procedure that is over a hundred years old, in which water is diverted out of the river at specific points into near-natural filter basins on the floodplains. There it is pre-cleaned through layers of sand and by micro-organisms in a more or less natural way. It then seeps through into the groundwater and we pump it, with the natural groundwater, up to the waterworks.

How complex are the technical procedures at the waterworks?

That depends on the location. In the lower reaches outside Essen or Mühlheim, where the Ruhr is more heavily polluted, the waterworks use a flocculation process, activated carbon filters or ozone to remove pollutants, as well as the standard procedure. On top of this we have reached an agreement with the state

government of North Rhine-Westphalia to introduce further purification stages in the other waterworks as well.

Why?

In 2006 there was a great outcry because PFTs were found in rivers in the Ruhr District. These are perfluorinated tensides, which are used in making products such as Teflon pans and weatherproof textiles. PFTs accumulate in the body and are harmful to health. Since then we have analysed the Ruhr regularly for such microcontaminants. And we have found a broad spectrum: chelating agents, fire retardants, pharmaceuticals, X-ray contrast agents – so substances that occur in industry as well as in everyday products. Although they are not directly hazardous in such small quantities we must nevertheless take precautions.

How exactly do you intend to remove theses substances from the water?

There is a wide range of technologies for this: adsorption on activated carbon, flocculation filtration, ozone splitting, ultrafiltration using a membrane filter. Most waterworks on the Ruhr intend to install some of these technologies by 2018. In doing this we are setting an example to the whole country, as microcontaminants are found in almost all rivers across Germany, not only in the Ruhr.

Will water charges go up because of this?

We estimate investment costs of at least 350 million euros. Therefore the price of water will have to rise by around 20 percent per cubic metre in the coming years. For an average four-person household that amounts to an extra 36 euros a year – so just about the cost of a cinema ticket each. That is really not much for clean drinking water.

A few months ago the EHEC bacteria caused a huge stir – was that justified?

EHEC is similar to the E.coli bacteria present in all water. E.coli is killed by disinfection at waterworks, so EHEC bacteria would also be reliably destroyed.

When new substances or bacteria crop up in the water and hit the headlines, how do you react?

We have long been holding meetings with representatives from farming and industry to discuss problems as they arise. As a result of such cooperation we are succeeding, for example, in getting certain industrial substances replaced by less toxic or more degradable alternatives. My experience tells me that, as there will always be new problem substances in the water, you have to keep talking – to the public, and of course to those responsible.

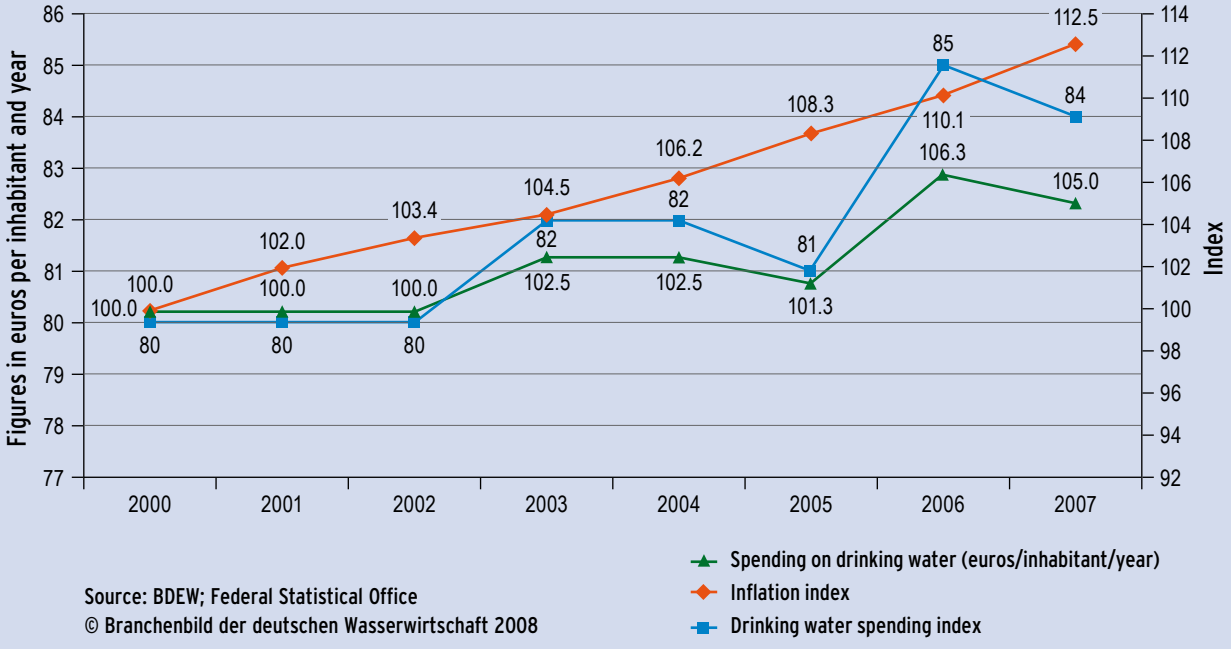
What has drinking water got to do with energy generation? At first glance not much. However, on closer inspection there are definite connections. An example of this is what is known as fracking, a method of gas extraction causing controversy among environmentalists and geologists. With fracking gas is not extracted as usual from cavities, but from layers of rock deep underground, in which it is locked up. To shatter the rock pressurised fluid is injected at depth. The gas is then released upwards through the fissures that are created.

Fracking can pose a risk to groundwater, because layers carrying groundwater can be penetrated during deep drilling. Moreover chemicals from the fracking fluid can leach into groundwater. While this method has long been practised in the USA, there is comparatively little experience of it in Germany and Europe and no clear statutory regulations. However, as here in Germany new sources of gas are always being sought, the Federal Environment Ministry is recommending detailed research into the impacts of fracking. Only when reliable information is available which ensures the safety of the procedure for German groundwater supplies, can the possibility of its use be considered.

German laws such as the Federal Water Act and the Plant Protection Act also contain provisions which indirectly help to protect drinking water. In order to protect bodies of water that are used for drinking water abstraction from negative impacts such as from fertiliser and plant protection products, the *Länder* can use statutory orders based on the Federal Water Act to establish water protection zones. Within water protection zones certain activities which endanger the quality of the drinking water are prohibited or permitted only to a limited extent. Owners of land which falls within a water protection zone have an obligation to protect the water resources.

Drinking water is and will remain our number one means of survival. It is difficult to assess what drinking water provision will look like in the future. The impacts of climate change, of an ageing society, and of high costs for the maintenance of water mains and treatment plants are all major challenges.

Annual consumer spending on drinking water compared to inflation



Source: BDEW; Federal Statistical Office

Water use in Germany

Land	Water supply companies [1]	Water abstraction installation [2]	Water abstraction [2]				
				of which			
			total	Groundwater	Spring water	River bank filtrate and enriched groundwater	Water from rivers, lakes and reservoirs
	Number		1,000 m³				
Year	2007						
Baden-Württemberg	902	2,431	620,614	343,421	126,047	4,614	146,532
Bavaria	1,878	3,436	898,386	677,154	149,046	48,687	23,499
Berlin	1	8	181,844	45,230	–	136,614	–
Brandenburg	96	465	150,490	136,720	–	13,770	–
Bremen	2	3	8,298	8,298	–	–	–
Hamburg	1	13	68,972	68,972	–	–	–
Hesse	394	1,935	361,587	273,148	44,515	43,924	–
Mecklenburg-Western Pomerania	53	447	92,402	78,108	1	2,732	11,561
Lower Saxony	232	383	556,330	482,212	11,638	1,435	61,045
North Rhine-Westphalia	424	794	1,197,923	475,334	21,762	513,417	187,410
Rhineland-Palatinate	207	1,281	234,528	165,444	34,561	25,020	9,503
Saarland	37	76	66,163	63,995	2,168	–	–
Saxony	94	479	224,785	59,016	14,106	60,333	91,330
Saxony-Anhalt	45	161	123,846	56,843	1,604	22,627	42,772
Schleswig-Holstein	382	429	203,824	203,645	–	–	179
Thuringia	85	705	130,099	49,525	18,060	327	62,187
Germany	4,833	13,046	5,120,091	3,187,065	423,508	873,500	636,018

1) Water supply companies with abstraction facilities listed according to location of headquarters.
2) Location of water abstraction installation.

Source: Statistical Offices of the Federal Government and the *Länder*

CHAPTER 3: WATER FOR LEISURE

German waters usually offer fans of swimming and water-sports undiluted pleasure.

Even if not every summer holds much sunshine in store in Germany, lots of people recuperate by spending their free time by or in the water. For many people swimming in a nearby lake, relaxing by the North Sea or the Baltic, or a fishing weekend with friends are among their favourite leisure activities.

Germany has more to offer water-lovers and people seeking relaxation than many imagine. In 2010 more than 1,900 rivers, lakes and reservoirs and 370 bathing beaches on the North and Baltic Seas were officially registered. Here in Germany there are over 3,000 campsites, of which around 700 are right by the water and offer swimming and water sports. We have the largest number of leisure pools in Europe – the 400 or so facilities included in this range from health and wellness spas to fun and adventure pools for young people and families.

One can also experience water by bike: around 200 long-distance cycle paths covering more than 40,000 kilometres crisscross the country. Many of these follow the course of major rivers such as the Elbe, Danube, Weser and Oder-Neisse. Officially signposted routes also take cyclists along Lake Constance and the Baltic coast. Many fitness enthusiasts have long been aware that sport out in the open is a hundred times nicer and more relaxing than in a gym or fitness suite. Sailing, canoeing, rafting, diving and surfing are just a few examples of water sports which are attracting more and more people.

The most recent EU report on bathing waters for the 2010 season established that, compared with the rest of Europe, the 2,200 or more bathing locations in Germany were exceptionally clean: 99.5 percent of coastal waters and over 97 percent of bathing sites on rivers and lakes have good or even excellent status, and only a few are therefore contaminated with pathogens.

Nevertheless, health risks cannot be entirely ruled out. Bathing waters in the open on rivers, lakes and marine coasts can be contaminated with pathogens that stem mainly from discharges from sewage treatment plants or from runoffs from cropland or urban areas. Although in Germany they seldom cause disease, they can certainly lead to a high temperature, diarrhoea and vomiting.

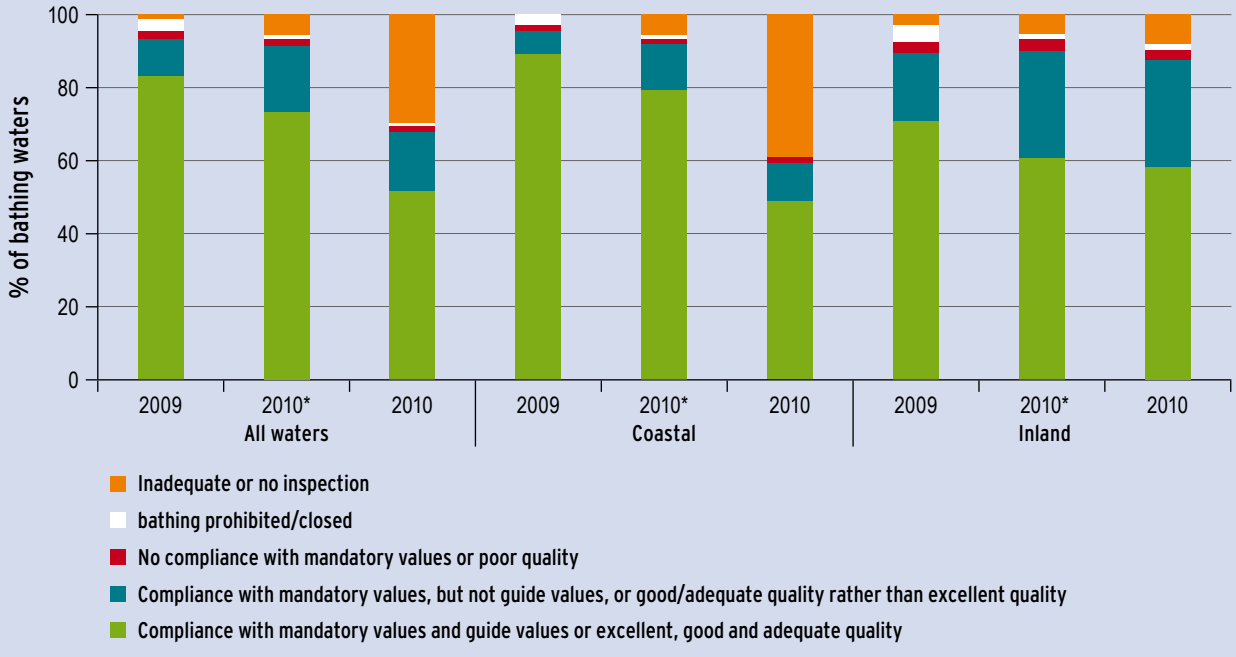
To minimise such risks as far as possible, scientists determined the level of pollution in all registered bathing waters in the EU using indicator organisms. These are particular bacteria which occur in the colon of humans and other mammals and are themselves relatively harmless. However, if these bacteria appear in high numbers, it is an indication for the inspection team that the water has been contaminated by faecal matter, sewage or runoff.

Canoeing offers a new view of the river and its banks

Everyone can help to keep the waters clean: never dispose of rubbish on the beach and especially not in the water, always use the toilets, don't apply sun creams and lotions immediately before swimming, don't throw bread in the water for the ducks or fish. Plus: leave the flora and fauna alone – reed beds and areas of vegetation along the water's edge are the habitat and breeding sites of countless plants and animals.

A lake is the landscape's most beautiful and expressive feature. It is earth's eye; looking into which the beholder measures the depth of his own nature. (Henry David Thoreau)

Bathing water quality in the European Union for the bathing seasons 2009 and 2010



* Less stringent regulations regarding frequency were implemented in these cases, therefore 42 days between sampling is permissible for reporting under EU Directive 2006/7, and bathing water quality in Greece is only evaluated for the period commencing end of July, from when monitoring figures are available.

Source: WISE databank on bathing water quality (taken from *Länder* annual reports)

Source: EUA 2011

Sport and leisure activities by and in the water can cause severe disturbance to flora and fauna.

Holidays – for many people seeking to recharge their batteries they are synonymous with sun, sea and sand. Anyone looking to relax by or in the water wants to be sure that there are no health hazards lurking there. In order to minimise the risks and keep a check on them, officially registered bathing waters in the European Union have been regularly monitored during the season since the 1970s.

Enshrined in the most recent amendment to the EU Bathing Water Directive is the precautionary consideration that in future a water profile must be produced for each bathing site, listing all the pollution sources that affect the quality of the water. Wherever possible these instances of pollution should be minimised. The public are regularly informed of the results of water analyses and, from 2012, about the bathing water profile and planned measures to improve the waters as well. Furthermore, the tendency towards pollution over the last three or four years at each bathing water will be determined, rather than just the contamination in a single season. In this way the monitoring will deliver more reliable and more realistic results than previously.

The EU bathing water report for the 2010 season confirms a significant trend: bathing waters in the EU have become considerably cleaner in the last twenty years. In 2010 on average around 92 percent of coasts and 90 percent of inland bathing waters in the EU were safe for swimmers and holiday-makers. However: in 2010 there was an increase in 'blind spots'. In total about 1,500 coastal sites and 1,200 inland water bodies were inadequately or never inspected by the member states. Greece, Italy and Hungary submitted very little or no data on pollution for one in every ten of their bathing waters. Anyone planning their next beach holiday or outing should therefore take a close look. Thanks to the Internet that is considerably easier nowadays than it used to be (see box).

Sport and leisure beside the water is fun and keeps you fit – almost no one gives a thought to the conflict with nature conservation. Activities in the countryside can, however, cause severe disturbance to flora and fauna and damage their habitats; for example, canoeists paddling about in areas with young and spawning fish, divers disturbing the underwater fauna, and boat-owners startling animals frightened by noise or damaging sensitive shoreline vegetation as they climb in and out of their boats.

Many sport enthusiasts are often unaware of the impacts of their activities on flora and fauna, so the Federal Agency for Nature Conservation has created a specialist information system on sport in the countryside and nature conservation. The portal provides comprehensive information on the impacts of sport and leisure activities on animals and plants and their habitats – including water sports of all forms. It gives background information on various animal species in their natural habitats, includes an extensive collection of literature and suggests examples of how conflicts can be resolved. 'NaturSportInfo' highlights the things that sports enthusiasts should be aware of when they pursue their hobby out in the country.

As well as the nature and sport information system there is the interactive Internet information platform 'Tauchseen-Portal' produced by the association of German sports divers. Comprehensive information on lakes and diving locations in Germany is available on this site.

Further reading:

- www.bfn.de/natursport/info/
- www.tauchseen-portal.de

How clean is my bathing lake? Anyone planning a swimming holiday or their next canoe trip wants the water to be clean. The quality of the water is also an increasingly important factor in enabling the tourist industry to attract visitors. Both the EU and the German authorities now make up to date information on the condition of the waters available online for everyone to see.

Länder information:
- www.bmu.de/binnengewaesser/verbrauchertipps/auskunftsstellen/doc/3553.php

EU bathing water report 2010
- www.eea.europa.eu/themes/water/status-and-monitoring/state-of-bathing-water

Interactive water information system for Europe (WISE)
- www.water.europa.eu/

CHAPTER 4: WATER TO BE TREATED

No matter whether it is used for washing, drinking or as a solvent and process water in industry, sooner or later water becomes wastewater. Every year homes, industry and commerce in Germany produce more than five billion cubic metres of dirty water. But that is not all: around three billion cubic metres of rain that cannot soak away through roads and other surfaces, is channelled into treatment works as well; added to that are considerable amounts of other water which seep through gaps in the sewerage system each year.

In Germany wastewater may not be fed untreated into rivers and lakes, regardless of whether it comes from homes, trade or heavy industry. The Federal Water Act (WHG) specifies that the pollutants contained in it must be reduced as far as the most up-to-date technology allows. Wastewater should be disposed of in such a way that the welfare of the general public is not compromised. That is why in most German communities it is compulsory to have mains water and sewerage: 96 percent of all German households are connected to the public sewerage system,

Wastewater seldom hits the headlines – no one really notices that there are over 10,000 sewage plants in Germany treating the torrent of dirty water from homes and industry, year in, year out.

and 95 percent to municipal treatment works. With these statistics Germany leads Europe.

In general wastewater undergoes three purification stages in municipal treatment plants. First, screens and settling basins remove solids and sand. Then billions of micro-organisms convert dissolved pollutants into harmless substances in large aerated basins. In the third stage certain bacteria break down mainly nitrogen compounds. Phosphorus is mostly removed from the water by chemical precipitation. The micro-organisms in the plant not only ensure clean water but also produce methane-based sewage gas, for example during fermentation. This can be used to produce heat and electricity directly on site to serve the treatment plant itself.

Our wastewater is reliably cleaned in more than 10,000 treatment plants in Germany

Wastewater disposal is a public service duty in Germany. Basically this means that cities and local authorities have responsibility for regulated removal and treatment, they levy charges and taxes for this and are obliged to maintain their treatment plants and sewerage systems in a condition that will also ensure efficient wastewater management in the future. The Federal Water Act leaves it to the municipalities to put out sewage disposal to private enterprise or to cooperate with private companies. However, according to the Federal Association of German Gas and Water Industries private contractors have only minor involvement in sewage disposal.

The Wastewater Ordinance regulates which substances have to be eliminated from dirty water and which should not be allowed into wastewater in the first place. Water from industry is often contaminated with salts, acids, heavy metals and organic substances that can pose a risk to man and the environment. For this reason the Ordinance differentiates according to the source of the effluent. For 57 sectors in all there are specific limits – from chlor-alkali electrolysis to sugar manufacture and from waste incineration to chemical pulp production.

A large proportion of industrial effluent originates from operations such as abattoirs, breweries, distilleries and dairies. The substances in it are mostly easily biodegradable, so these businesses are connected to public sewage treatment works. This is not the case for effluent from the chemicals, engineering or automotive industries, for example: this often contains substances that are not easily biodegradable and therefore mostly undergoes particular processes, for example using special membranes, in the companies' own treatment plants.

Sewage disposal companies have to adapt to the challenges of climate change and falling populations.

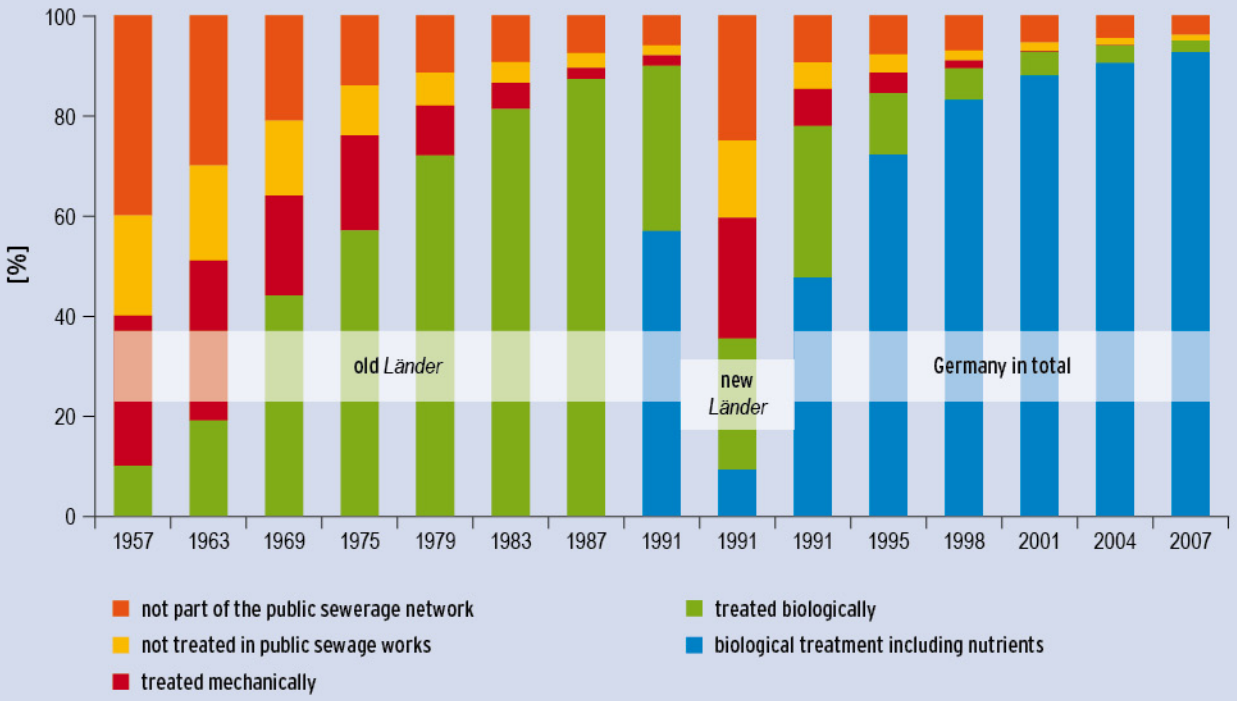
Despite the high degree of efficiency in German treatment plants, the situation in water purification is not perfect. In heavy rain so much water can pour into the treatment plant over a short period that the volumes of water only remain briefly in the basins and some of the rain, together with domestic sewage, passes untreated or poorly treated into the rivers. In heavy downpours pollutants from hard surfaces and zinc and copper from roofs are washed with the rain out of rainwater treatment plants into the water bodies. Therefore, according to the new Federal Water Act, if rainwater is not specifically discharged into a water body, it should soak away or be used for irrigation as locally as possible. The agencies responsible must examine whether it is better, ecologically and economically, to let rainwater drain away where it falls rather than to channel it into sewers and thus into the treatment works.

Wastewater treatment is expensive – we are always reminded of this when the local authorities send out their bills. Investment by the water industry in sewers and treatment plants amounts to several billion euros every year and is roughly comparable with investment in the electricity grid or in engineering.

A lot of people in Germany get worked up about rising sewage charges, and the taxpayers' association regularly complains that charges in Germany, and even within an individual Land, are subject to wide variations. According to a survey by the Federal Statistical Office charges for drinking water and sewage in 2010 were highest in Saxony-Anhalt and lowest in Bavaria. In that year the annual charge for a typical household with a potable water usage of 200 cubic metres and a property with 130 square metres of hard surface varied between 246 and 1,238 euros in North Rhine-Westphalia alone.

What at first glance appears to be gross injustice or variations in the standard of management by local authorities has completely understandable causes. The sewage costs for a community depend heavily on the extent and condition of the sewer network and treatment works. Furthermore, how the municipality assesses the depreciation of its installations has a major influence.

Waste water statistics up to 2007



Source: Federal Statistical Office

Considerable investments have been made in sewage treatment plants. And they have proved successful. Biological wastewater treatment with nutrient removal has become the standard in Germany.

Demographic change presents a major challenge for the sewage industry and also impacts on the costs. Population numbers are falling in many regions and communities, which results in lower volumes of wastewater. Less wastewater from homes and businesses leads to increased hygiene problems, because the water stays in the sewers for longer. Therefore the network has to be flushed through more often. However, at the same time expenditure on wastewater treatment remains almost constant, since the fixed costs for the sewer network and treatment works amount to around 80 percent and thus deter

Hospital effluent. There is much discussion in the media about trace substances in wastewater – especially since analysis has been able to detect even minute concentrations. In Gelsenkirchen they no longer just talk about it, they're cleaning the sewage. Since July 2011 a new type of treatment plant has been up and running at the Marienhospital which can eliminate even trace substances such as pharmaceuticals and x-ray contrast agents from 200 cubic metres of wastewater a day. The EU is shouldering half the 2.5 million euros' cost as part of the PILLS research project.

The technicians combined three treatment stages that up till now have been used mainly in industry and for drinking water purification. At stage one the wastewater goes into a biological stimulation pond, where micro-organisms break down most of the organic contents. This pre-treated water is filtered through ceramic membranes. A series of ozone reactors make up stage two. In these highly reactive ozone splits non-biodegradable pollutants into insignificant particles. At stage three powdered activated carbon adsorbs the last residues.

By the end of 2012 scientists want to examine how to combine and run the three treatment stages so that the process operates as efficiently and at the same time as cheaply as possible, as both the ozone stage and the activated carbon are expensive. Moreover, the operator, the Emscher river management association, wants to get official permission for the clean water to be re-used in the hospital rather than being drained away.

Heating with wastewater. Can heavily polluted wastewater be treated biologically so that not only clean water but also energy can be produced? At the municipal treatment plant in Bitterfeld-Wolfen chemical park, one of the most important industrial sites in east Germany, this is being done successfully with fermentation, whereby micro-organisms break the substances down anaerobically in water and in doing so generate energy-rich biogas.

At the heart of the plant are several 24-metre high stainless steel reactors. Into these is pumped effluent from a factory manufacturing methyl cellulose. This effluent contains large amounts of organic substances, but is also particularly high in salts. A high salt content in wastewater is normally toxic for micro-organisms, so the plant operators mix the effluent with domestic sewage to achieve salt levels that bacteria can tolerate. By doing this they have succeeded in getting the micro-organisms accustomed to salt concentrations twice as high as are normally considered tolerable. The icing on the cake: while breaking down the substances in the water the micro-organisms generate biogas, which the operators burn in three combined heat and power units to generate heat and electricity. The heat produced is used to bring the wastewater temperature up to a comfortable 37 degrees for the micro-organisms.

The treatment plant uses the electricity to meet its own needs. As the operators are not only treating industrial effluent, but by using biogas are also preventing several thousand tonnes of carbon dioxide per year, the Federal Environment Ministry has awarded the new plant a grant of 3.8 million euros.

mine the prices. A drop in wastewater volumes does not therefore result in a drop in charges. Quite the opposite: the costs have to be borne by fewer and fewer customers in the medium and long term.

As a rule saving energy is an effective way of reducing costs. That applies to treatment works as well. Sewage treatment plants are responsible for 20 percent of the energy requirement of German cities and towns; operating German sewage works uses the entire annual output of a modern coal-fired power plant, so producing around three million tonnes of the greenhouse gas carbon dioxide every year.

A study by the Federal Environment Agency concludes that the energy required by the plants can be reduced by more than a fifth – for example, by better pumps, low-energy aeration of the purification basins and more efficient treatment of the sewage sludge. Moreover, considerably more biogas can be extracted at treatment plants than at present, to generate clean electricity and heat. That is why in the next few years the Federal Environment Ministry intends to promote designs and technologies that make sewage treatment plants more energy-efficient and therefore more environmentally friendly, and why in September 2011 it awarded grants totalling almost 10 million euros to businesses.

How the infrastructure for treating our wastewater will evolve in future is not yet clear. On the one hand the new Federal Water Act strengthens the case for more decentralised sewage disposal with small-scale treatment plants. The local authorities can decide whether large or smaller treatment works are more fit for purpose and better for the residents, because falling population figures make a nonsense of large-scale plants and costly sewerage networks.

On the other hand climate experts are predicting that there will be more ‘heavy rain events’ in Germany as a result of global warming. For that reason there can be no general narrowing of the sewers, because they will have to take the temporary excess rainwater. Instead the construction of additional overflow basins for rainwater should be considered, warns the Federal Association of German Gas and Water Industries.

Another challenge for scientists is the presence of new pollutants in wastewater. These include drug residues, antibiotics used in livestock rearing and chemicals that exhibit hormone-like effects even in minute quantities. Conventional treatment technology is not good enough to remove theses trace substances. Although the first technologies exist for eliminating such substances, for example special membranes and oxidation procedures, they are expensive, and in any case there are as yet no statutory limits for trace substances in wastewater for sewage plant operators to work from.

CHAPTER 5: WATER FOR PRODUCTION

Without water our supermarket shelves would be empty. We would have no cars or computers, no medicines or plastics, no paper in the office and nothing to wear. There would be no electricity from power points and no toothpaste from the tube.

Water is the lubricant for all industrial production. Water is used to manufacture thousands of chemicals, to process food, to clean surfaces, to extract metals and ores from the soil and to generate electricity. In Germany the manufacturing, mining and energy industries use around 30 billion cubic metres of water a year. Most of this – about 22 billion cubic metres – is used by energy generators to cool their power stations. The remainder is divided mainly among four high-volume consumers: the chemical industry, mining, metal processing and paper manufacture.

Businesses would benefit from a more sparing and sustainable use of water. Those who produce less effluent pay lower taxes and charges, have to buy in less clean water and avoid the need for large, costly treatment plants. That is why almost all sectors of industry have significantly reduced their water consumption in the last ten to fifteen years. This is particularly beneficial in the chemical and food industries, where energy, water and raw materials can represent up to 40 percent of the total costs. Moreover, in its national sustainability strategy, Germany has set a target for industry to double its 1994 resource productivity by 2020. Saving water plays an important part in this.

There are many ways for businesses to save water nowadays. Often these are very simple measures which make a significant difference. For example, a dye works can save a lot of water just by cascade rinsing the dyed products and re-using the less dirty water from the last rinses in the first cascade stage next time. If cooling or process water is recycled the clean water required can drop by 50 or 60 percent. Water can also be saved in the food industry by dry pre-cleaning of the surfaces of metal components and pipes instead of using water. In any case it does not always have to be costly tap water; rainwater that has first been filtered and softened is good enough for many industrial processes.

In recent years German industry has had some success in saving water. The average re-use factor is 5.8, which means that every cubic metre of water is used about six times before it is pumped out as effluent.

Modern production processes treat water and re-circulate it

When companies are using water economically and intelligently like this, experts refer to it as production integrated environmental protection. It is by far the better option than conventional end-of-the-pipe conservation of the environment, which involves the installation of filters and other technologies to collect pollutants at the end of the production process. That is expensive and does little for company profits. In the case of production integrated environmental protection the company has to invest in technical equipment and systems at the outset – but the investment mostly pays for itself within months or a few years and after that cuts the company's costs considerably every year.

Experts estimate that water consumption in industry can still be reduced significantly in the next few years, mainly through rainwater use, water-saving cleaning technologies and closed cycles.

There is no water meter that can show how much water each consumer in Germany truly uses, for what really counts is the 'virtual water', i.e. the total amount needed to manufacture a product.

If industries cut water use and the pollutants in effluent fall, it will not only be the businesses themselves that feel the benefit: the treatment plants will suffer less contamination from toxic substances, the runoff from the treatment ponds will be cleaner, the treatment plant operator will pay less sewage tax and – last but not least – fewer substances will get into rivers and groundwater.

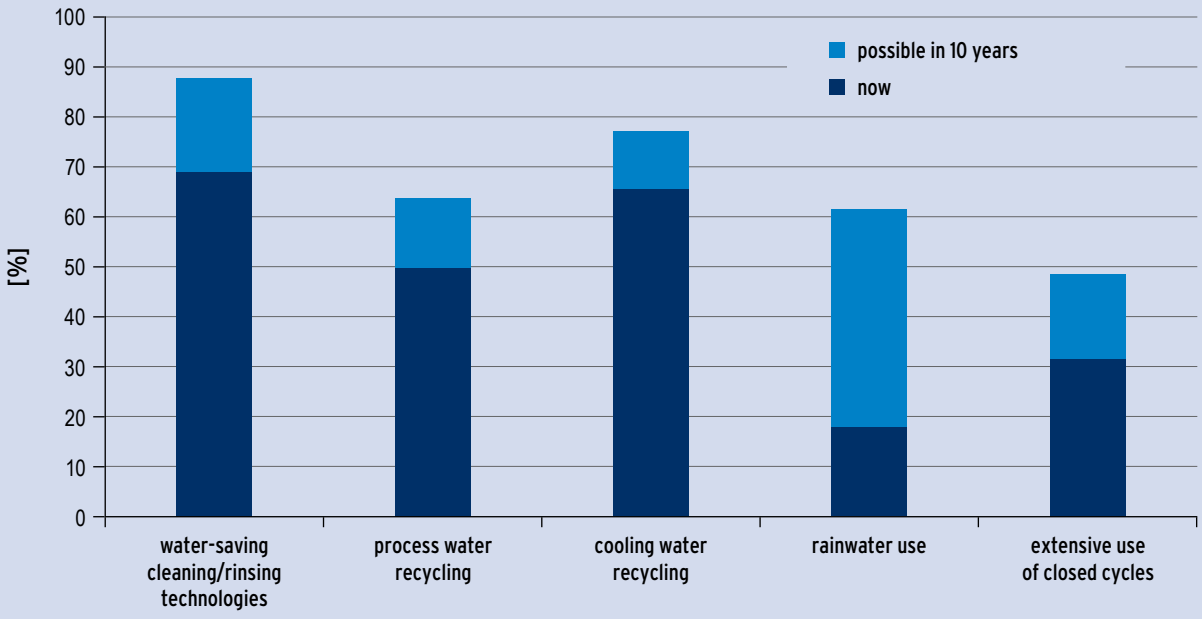
However, a look at German manufacturers only reveals part of the amount of water that modern consumption actually uses. There is not only water in the pipes, plumbing, reactors and containers belonging to German businesses. Indirectly and unseen it is 'embodied' in practically every commodity and travels in processed products all over the world. How much each individual really consumes can only be estimated on the basis of 'virtual water'.

Here are a few examples: producing a cup of coffee takes approximately 140 litres of water, mainly to grow the coffee beans. A steak takes 2,800 litres – water with which the cattle are watered and the fodder grown. 17 litres are needed for a glass of beer in the evening, principally for growing the barley. Producing a cotton T-shirt requires an input of 2,000 litres of water on average, while every sheet of white A4 paper has a virtual content of ten litres.

Since freshwater is very unevenly distributed across the world, virtual water has to be seen in relation to the water stress in a region. For example, the water requirement for a tomato grown in the dry region of southern Spain has a more negative evaluation than a tomato thriving in rain-soaked Germany. The same applies to cotton, which is often grown in very dry regions. According to a UNESCO study, EU imports must accept a fifth of the responsibility for the fact that the Aral Sea is drying out, as its tributaries are being used for irrigating the cotton fields in Uzbekistan.

Despite its wealth of water Germany is a net importer, because it brings in more water than it exports via the multitude of imported products. An average

Water consumption in German industry



Source: Hillenbrandt, T.; Böhm, E. (2008): Trends in industrial water use in Germany Abwasser, Abfall 55 (2008), 8, pp. 872–882

There is well-founded concern about the protection of water bodies when dealing with substances hazardous to water. It is the operator's responsibility to comply with important safety criteria.

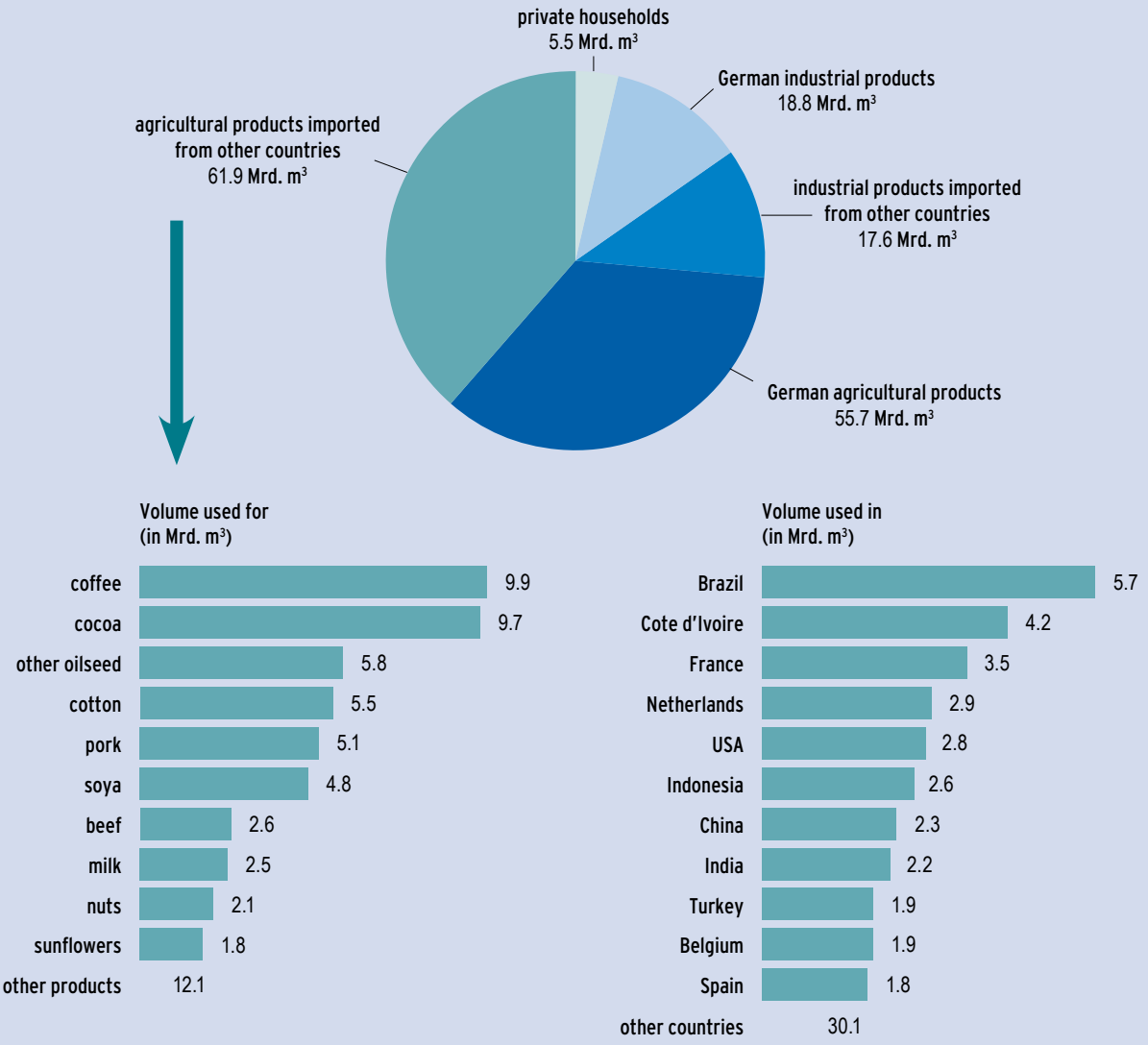
consumer here in Germany has a virtual water consumption of approximately 1.5 million litres per year. Environmentalists point out that it would be more sensible if Germany were instead to manufacture water-intensive goods that are sold in water poor countries. Conversely, countries with water scarcity should produce export goods that need little water. In reality the opposite happens. Although globalisation makes everyday products cheap and available everywhere, the price does not reflect the reality.

Protection from substances hazardous to water. Heating oil tanks and petrol stores, galvanised baths and liquid manure containers – many private, public and industrial installations in Germany contain substances that are hazardous to water. If they leak out or seep into the ground they contaminate the soil and groundwater and pose a health risk. The Federal Environment Ministry is currently working on a new ordinance for managing these installations safely. It provides for special regulations, which – depending on the quantity and level of hazard – are intended to ensure that the installations are constructed and operated in an environmentally sound manner.

Amongst other things it specifies that containers of substances toxic to water should be sound for the entire duration of their use. The operator is personally responsible for ensuring that no leaks occur and that his installation is run in accordance with the regulations. Work on the installations may only be carried out by specialist companies. The new ordinance will replace the various ordinances in existence in the *Länder* on handling substances toxic to water and, as the keystone of German water legislation, will lay down a uniform national safety standard and lead to greater legal certainty.

Virtual water

Germany's water footprint: Germany consumes 159.5 billion cubic metres of water each year



Source: WWF Germany

That is because all goods, food and materials use water in their production – water that remains invisible to us consumers and is barely reflected in the price, yet is crucial for the sustainability and resource efficiency of our production and consumption.

Further reading:

- www.pius-info.de
- www.virtuelles-wasser.de

CHAPTER 6: WATER FOR AGRICULTURE

Compared with industry or energy generation, agriculture uses a relatively small amount of water, but it is the only sector that operates in the open air. This has consequences for the aquatic environment: since only some of the fertiliser and pesticide is used, broken down and retained in the soils and crops, many different substances enter the environment unchecked. They are washed out into rivers and lakes with the rain, seep into groundwater, reach coastal waters and can lead to substantial ecological damage everywhere.

No one disputes that agriculture in Germany is an indispensable provider of resources for the feedstuffs and food industry and, more recently, increasingly for the energy industry as well, and is an important economic sector. Despite its industrialisation Germany is a highly developed agrarian state; around 48 percent of Germany's total surface area is used in crop and livestock production. However, agriculture does not set a good example when it comes to protecting the aquatic environment.

In the case of industrial production systems and sewage treatment plants strict regulation and technical progress have achieved major successes over the last decades in reducing releases of substances to the environment. There have been no comparable reductions in agriculture. For instance, in 30 years – between 1975 and 2005 – its nitrogen emissions fell by only about 22 percent. Phosphorus loadings have actually remained at almost the same levels for 20 years. Since direct emissions from factories and other 'point sources' have fallen, agriculture's contribution to pollution of the aquatic environment has risen in proportion. Over 70 percent of all nitrogen and more than 50 percent of all phosphorus loadings in Germany's waters come from agriculture.

Representative readings from 2008 show that groundwater in Germany – our most important source of drinking water – is often contaminated with nitrates.

Nitrogen and phosphorus as fertilisers are essential for the growth of many cultivated crops, but the problem of inputs of these nutrients into the aquatic environment has remained unresolved for very many years.

The cultivation of asparagus, like that of many other vegetables, leads to large amounts of nitrates entering soils and groundwater

At nearly15 percent of all measuring sites the nitrate content was above the Groundwater Ordinance threshold of 50 milligrams per litre. More than one in three samples even registered a significant to severely raised nitrate content. However, nitrogen and phosphorus also pollute streams, rivers and lakes just as much as coastal waters and seas. The problem is that nitrogen and phosphorus do not only accelerate the growth of crops in the field, but also of certain plants and algae in the water. As a result the oxygen content of the water falls and the ecological balance is disturbed.

Of course there are laws which should restrict the input of substances from agriculture into the aquatic environment. The European Nitrates Directive, for example, contains requirements to reduce inputs from agricultural sources. Germany has implemented these requirements through the Fertiliser Ordinance. It lays down, for instance, that farmers must establish the actual fertiliser requirement of their crops, that they may not apply more fertiliser than the plants really need and that they take account of the nutrients already available in the soil when calculating the amount of fertiliser. Farmers must not apply fertiliser when the ground is flooded, waterlogged or frozen. In accordance with the Federal Water Act authorities can for example restrict the application of fertiliser and plant protection products in water protection zones.

Irrigation is seldom necessary because there usually is sufficient rain.

It is not only nitrogen and phosphorus that damage water bodies, but also heavy metals and plant protection products. 20 to 40 percent of heavy metal loadings in surface waters are a result of erosion or surface and drainage runoffs from agricultural land. Also relevant here: other sources of pollutants, especially from industry have been substantially reduced in the past, so that the proportion from agriculture has increased relative to the total amount of pollution.

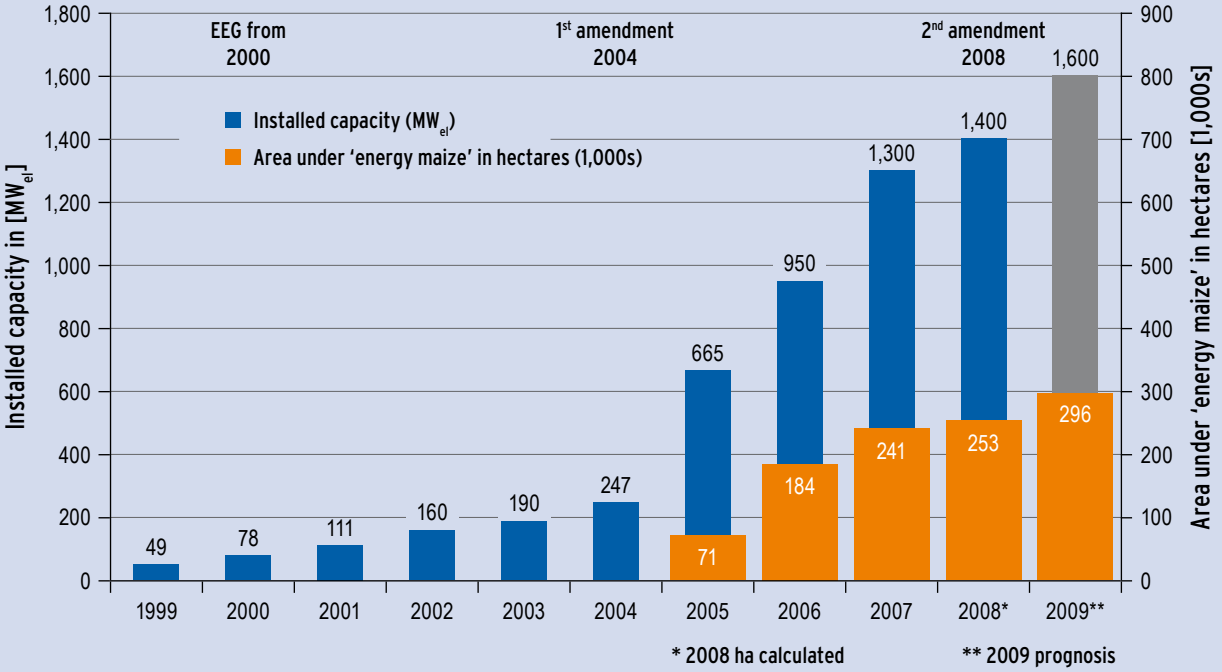
The role of agriculture is changing in Germany. The aim of the Federal Government is to expand considerably the proportion of renewable energies by 2030. Bioenergy is one of the essential building blocks of this policy. Already, for example, biodiesel is manufactured from rapeseed and sunflower oils, and bioethanol, which is added to conventional petrol (E10), is produced from sugar beet and corn. Maize is the main raw material for producing biogas, from which electricity and heat can be generated.

The Renewable Energy Sources Act (EEG) promotes the cultivation of renewable resources for energy generation. Biogas plant operators receive a set feed-in tariff for every kilowatt hour of electricity produced not only from energy crops, but also from liquid manure, agricultural residues and municipal organic waste. This is a lucrative business for farmers and municipal works departments, not to mention private operators: between 2006 and 2010 electricity generation from biomass increased fourfold, while in the same period the area under cultivation for the substrates grew from 160,000 to 650,000 hectares.

Water conservationists view this development with mixed feelings. Every year sees an increase in the area of farmland under crops that are used for the production of electricity, heat and fuel rather than for fodder or food. Oilseed rape as the raw material for biofuels and maize as the substrate for biogas generation predominate.

Water conservationists view the rapid expansion of land under cultivation with energy crops such as maize and rapeseed with mixed feelings.

Development of area under maize cultivation and biogas facilities in Germany



Development of installed capacity from biogas and area under 'energy maize' in Germany
Source: Federal Environment Agency

Maize in particular is enjoying a real boom in cultivation as an energy crop: it makes few demands on the soil, can be processed cost-effectively and contains many hydrocarbons that can be fermented into energy-rich methane in a biogas plant. In 2010 almost 20 percent of the total area of cropland across the whole of Germany was planted with maize. The German Advisory Council on the Environment estimates that the area under maize for energy production will double again by 2030. In the traditional arable farming regions of northwest and south Germany the proportion of land under maize has already reached 45 to 70 percent in some districts.

From the perspective of water protection both rapeseed and maize are problem crops. They need a comparatively large quantity of fertiliser and plant protection products, and they are driving fodder and food crops from the fields. Grassland is being ploughed up to plant energy crops. Biodiversity is falling. Even the Federal Government's experience report on the Renewable Energy Sources Act compiled in May 2011 ascertains that problems from limited crop rotation, soil erosion, use of plant protection products and fall in biodiversity are exacerbated by the cultivation of maize. A further problem is that, especially in regions

Maize creates problems with regard to water protection. It should not be cultivated excessively.

with a lot of biogas plants, the fermentation residues from the biogas containers are spread on the fields in addition to slurry and other fertilisers. It is often not only nitrates but also heavy metals and industrial chemicals that enter the waters with the fermentation residues.

As yet the cultivation of energy crops has not been linked to provisions for water protection in either German or European policies. Although in the latest amendment to the Renewable Energy Sources Act an upper limit for the use of maize in biogas plants will be introduced from 2012 (the 'maize cap'), this amendment also sets out incentives for the use of other crops and organic matter in biogas plants. The Sustainability Ordinances pertaining to electricity and biofuels, passed in 2009, also bind the cultivation of energy crops to certain environmental and production standards for the first time. These apply to the use of crops as liquid biomass and as raw materials for liquid or gaseous biofuels.

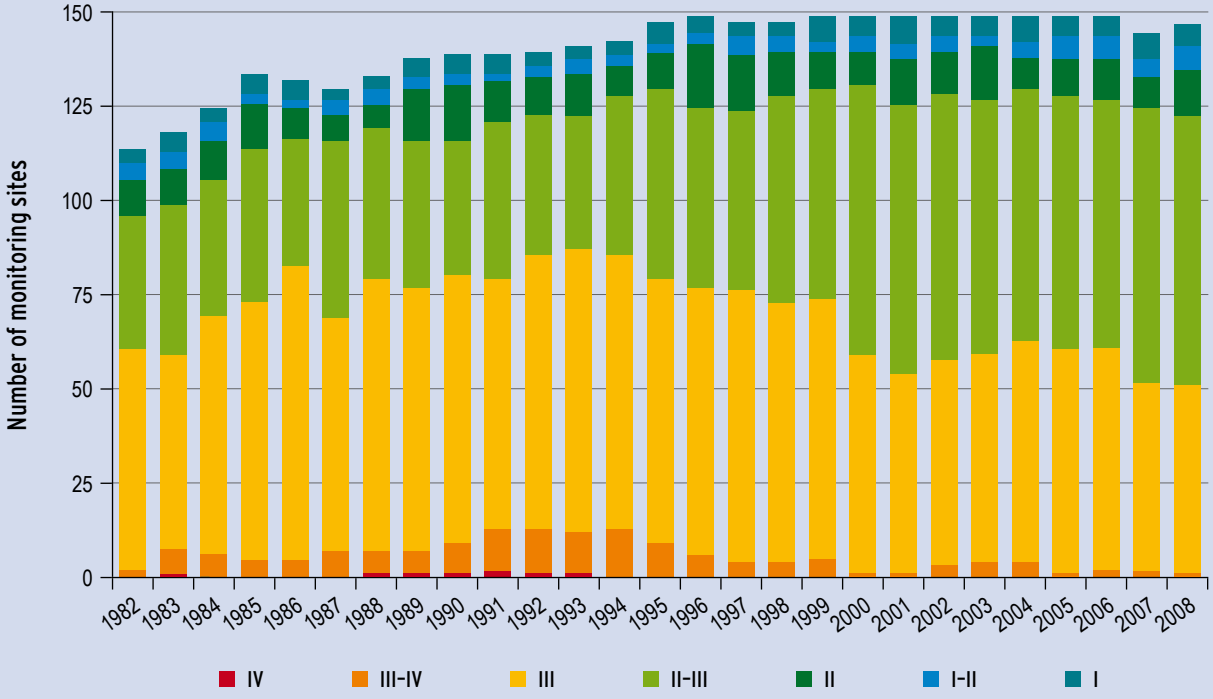
However, from the perspective of water protection these approaches do not go far enough. Instead the principles of farming in a manner appropriate to the location and which protects the aquatic environment should apply to growing energy crops as well. For example, water suppliers are demanding that, to protect groundwater, grassland should not be ploughed up to grow energy crops and that state funding for the crop should be linked to a farming regime which causes less pollution in our waters.

Organic farming as an alternative to intensive agriculture promises better protection for waters. Organic farming produces emissions as well but, because no mineral nitrogen fertiliser is used, there is less surplus nitrogen and a lower risk of nitrate leaching out. Nor do organic farmers use synthetic chemical plant protection products.

In its sustainability strategy the German government is pursuing the aim that 20 percent of agricultural land should be managed organically. However, according to Federal Statistical Office figures for 2010 only five percent of this land was under organic production, including in East Germany, where there are now twice as many organic farms as in the old West Germany. The number of organic farmers is growing year by year; nevertheless organic farming will continue to be the exception for a very long time.

Nitrate in surface waters

Quality classification for nitrate nitrogen (LAWA [German working group on water issues of the *Länder* and the Federal Government] monitoring network)



Federal Environment Agency, LAWA data 2009: Federal Environment Agency, compiled according to LAWA figures

It takes perseverance to protect our water bodies. Ecological progress in the agricultural sector is only slowly improving groundwater quality.

CHAPTER 7: WATER FOR ELECTRICITY

Reservoirs serve the abstraction of drinking water, water regulation, flood protection and energy generation

Water is a powerful force. Rivers can move mountains and dislodge thousands of tonnes of sediment. Water can snap trees in half and shift houses from their foundations. For over a century we have been exploiting the force of water in rivers and dams. Energy companies generate electricity from it with absolutely no fossil fuels and no emissions. Hydropower is therefore the oldest form of renewable energy and one of the most important; from a global perspective it is now the second largest source of clean electricity.

In 2010 hydropower plants in Germany produced almost 20 terawatt hours, corresponding to nearly 3.5 percent of the country's electricity consumption. After wind and biomass hydropower is the third largest renewable energy source in the country. The majority of the power plants are in Bavaria and Baden-Württemberg, since here the foothills of the Alps provide a good head. Most of the energy is generated on just nine major rivers, including the Rhine, Inn, Lech, Moselle and Danube. Around 400 large power plants, each with an installed capacity of over one megawatt, produce more than 90 percent of the electricity. The rest comes from more than 7,000 small hydro plants.

The principle behind the plants is simple: fast-flowing or dammed water transfers its energy from motion to a turbine and sets it in fast rotation. This turning motion is conducted directly or via a drive wheel onto the shaft of a generator, which then converts the mechanical energy into electrical energy, that is, into electricity. The higher the head of water and the greater the water volume, the greater the amount of electricity produced.

Hydropower has a distinct advantage over sun and wind: water flows almost all the time, even if the water level can fluctuate widely from season to season. Therefore hydropower plants can generate base load electricity round the clock. By contrast, wind turbines and solar power installations only supply energy if the wind is strong enough or the sun is shining.

Hydropower plants provide both base load and peak load electricity, and are less dependent on seasons and weather than sun and wind power.

The Federal Water Act and the Renewable Energy Sources Act strengthen the position of water conservationists in the building and operation of hydropower plants.

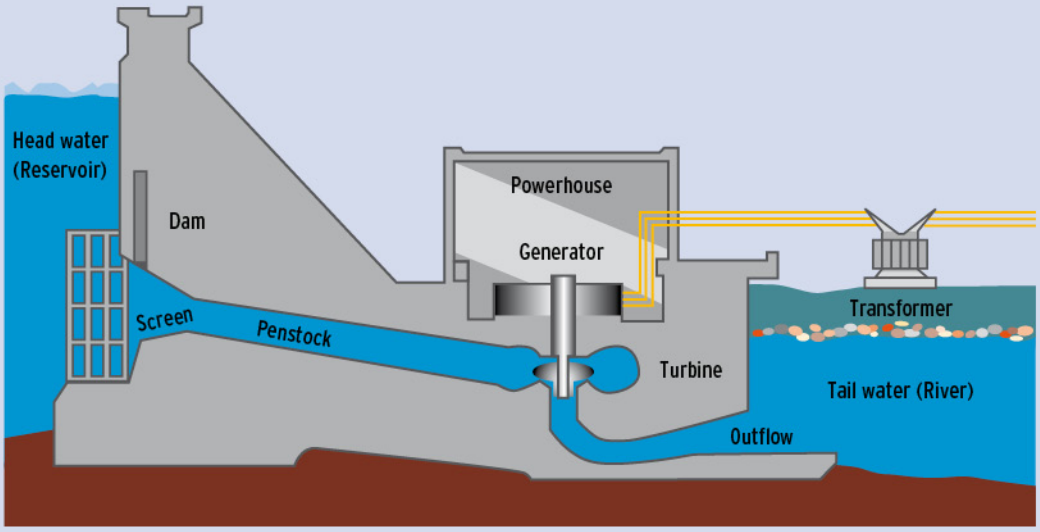
Hydropower also provides for peak loads, that is, for periods with especially high electricity demand. To do this the water is pumped to a higher level during periods of adequate supply in storage power plants. If electricity consumption then rises sharply – in the course of the day, at times such as in the early morning and in the evening – the water flows back down with considerable force and in doing so sets turbines in motion. With the further expansion of inconsistent wind and solar power the need for efficient electricity storage is increasing. That is why a series of new facilities and also the expansion of existing pumped storage power plants are currently under discussion in Germany.

Although clean and climate-friendly, hydropower has disadvantages as well: pumped storage units require the creation of new artificial lakes. Furthermore, the plants, with their weirs, dams and powerhouses cut off the route for migratory fish and other aquatic organisms. Fish end up in screens and turbines and are injured or killed. A chain of reservoirs with several power plants one after another can endanger entire populations.

The new Federal Water Act of 2010 addresses this problem. The damming, abstraction and diverting of water is only permissible if enough water is left in the river bed. The Federal Water Act lays down specific ecological requirements for hydropower plants for the first time. Thus a dam can only be built and operated if it does not represent an insurmountable hurdle for aquatic organisms and if the flow volume necessary for ecosystems is unimpaired. In addition authorities can only license hydropower plants if appropriate measures are taken to protect the fish; these might include fine screens with small gaps between the mesh, fish ladders and bypass channels. These measures are to ensure that the creatures can pass unharmed through hydropower plants in the course of their migration.

The Renewable Energy Sources Act (EEG) also strengthens the position of water conservationists. Energy generators who improve the environmental aspects of their hydropower plants can receive a higher tariff for the electricity produced. With this the EEG is providing incentives, especially with regard to the modernisation of hydropower plants, to optimise the use of hydropower while at the same time improving the aquatic environment. There is no shortage of ideas on how to do this: researchers at the Bauhaus-Universität Weimar, for example, are being funded by the Federal Environment Ministry at their own research facility to study how fish migrating downstream can be carried past a water turbine more or less by conveyor belt. Further laboratory and field studies will have to show whether the idea is technically feasible.

How a hydropower plant works



Source: Federal Environment Agency

Bristle pass – another good means of ensuring the continuity of streams

Making hydropower plants more environmentally acceptable is no easy matter. This was shown by a research project by the Federal Environment Agency in close consultation with the Weser River Basin Commission. The experts investigated whether a salmon population introduced into an intensively used river can maintain itself without human intervention. The studies showed that for this to happen the requirements for fish passage facilities for upstream and downstream migration would be extremely high. A stable population can only develop if more than 95 percent of the salmon migrating up or downstream can negotiate every single hydropower plant on their route without difficulty.

While the expansion of wind and solar energy continues in Germany by leaps and bounds, the potential for electricity generation from hydropower is largely exhausted. Experts estimate that existing hydropower plants can increase electricity production by about a further 15 percent through modernisation and expansion. However, that will not happen overnight, or indeed in the near future; space for additional hydropower plants on German rivers is limited, and the planning and licensing process for new plants takes many years. Major investment would be needed in the construction of the plants to cushion the impacts on aquatic ecology and the wider environment. For this reason new hydropower plants in regions where they have not yet been installed will remain the exception in Germany.

Ocean currents, tides and waves hold huge potential for clean electricity.

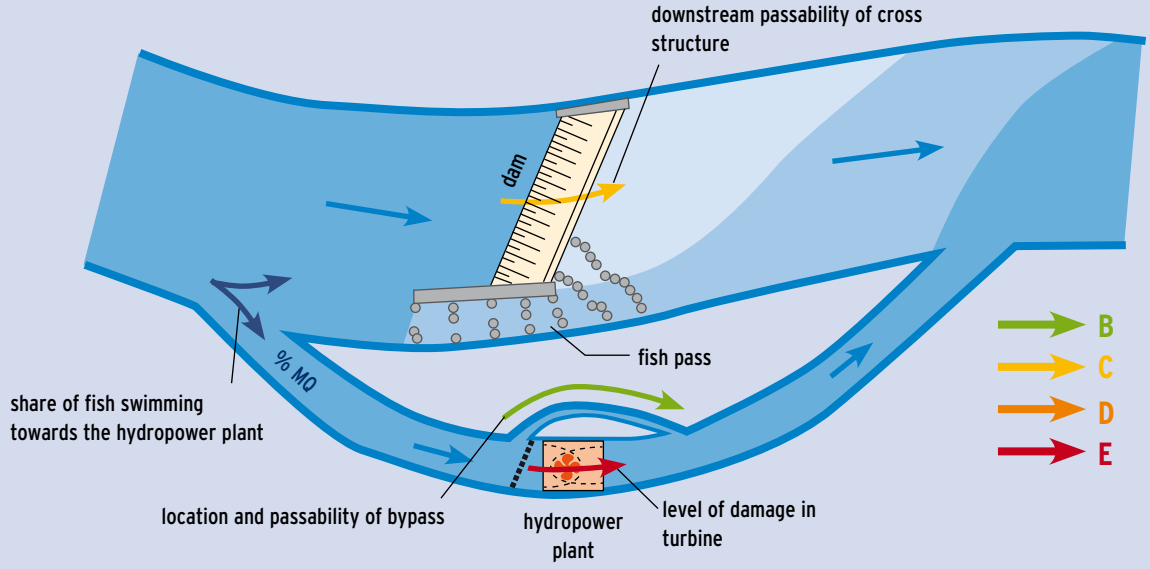
Electricity can also be generated in the sea, because ocean currents, tides and waves can produce particularly powerful forces. The current can be especially strong near the coast, in bays and in straits. The Federal Environment Ministry has been promoting the development of components for novel power generation technologies since 2002. A special turbine that can convert the power of tidal currents into electricity is currently being tested in partnership with businesses and universities.

Bremen opts for hydropower. One of the few new larger hydropower facilities being built in Germany at the moment is in Bremen. From late 2011 it is expected to supply electricity to around 17,000 homes and thereby prevent 35,500 tonnes of the greenhouse gas carbon dioxide from entering the atmosphere each year. In an environmental respect the new plant on the old Weser weir aims to set standards: the design includes a fish conservation concept consisting of several aids to both upstream and downstream migration combined with an effective guard to prevent fish passing through the turbines. Thus three diversions, known as bypass systems, and a fish ladder are planned. In the winter only a third of the water in the Weser will be used to generate electricity; the remaining two-thirds will be left in the river and will provide the fish with a simple migration route in the nearby weir. Furthermore, organisms in the water will be prevented from swimming into the turbine unit by protection systems consisting of coarse and fine mesh screens. To protect small fish the plant uses special turbines constructed in a way that minimises the risk of injury. However, as the Weserkraftwerk Bremen GmbH reports on its website, such exemplary fish conservation measures come at a price, which results in substantially higher costs compared with earlier designs for hydropower plants of this size.

Scientists and companies worldwide are working on the development of the first marine energy plants, although the technology is still in its infancy. This is because the marine environment makes great demands on equipment and material: salt water attacks almost all materials, storms produce powerful energy, and the maintenance and repair of underwater installations is difficult and expensive.

As yet there are no marine energy plants for electricity generation in operation in German waters, and the potential for them in the North and Baltic Seas around Germany is rather limited. In other countries, however, such as off the coasts of Britain, the currents are very productive. Thus marine energy offers real opportunities for German companies that are already working successfully in maritime technology and logistics.

Example of the assessment of fish migration at a diversion power plant



Source: Federal Environment Agency

There are different possibilities for fish to pass through a hydropower plant. The green arrow is preferable to the way through the turbine (red). MQ stands for average flow.

CHAPTER 8: WATER FOR SHIPPING

The advantages of shipping are low costs and large load capacities

Few countries use their rivers as intensively as Germany does. More than 7,350 kilometres of federal waterways traverse the country – three quarters of them are busy rivers such as the Rhine, the Moselle, the Elbe and the Weser, and there are also 1,500 kilometres of artificial canals like the North Sea-Baltic Sea Canal and the Main-Danube Canal.

People who do not live right on a major river are not really aware of the fact that barges transport approximately ten percent of all freight and account for a quarter of the entire transport volume. They transport around 230 million tonnes of goods per year, mainly construction materials, ores, coal and steel, via German rivers and canals. Important German industry sectors are directly dependent on barges: for example, the steel industry moves more than 40 percent of its loads by water. A large proportion of hazardous substances such as petrol, heating oil, acids and liquefied gases also reach their destination by ship. Nor should we forget the 17 million or so tourists every year who enjoy the scenery and the countryside from on board ship. That is why well-maintained waterways are of great importance to the national economy and why we cannot do without them in future.

The Rhine is a very busy river, but there is still room for restoration.

New life for the Rhine. In the 1970s the Rhine was still regarded as 'the most romantic sewer in Europe'. Today the river has largely overcome the acute pollution, but its regulation to a waterway has deprived it of its diversity and dynamic and has destroyed many natural habitats. Can more space for nature be recreated successfully on Europe's busiest inland waterway without adversely affecting shipping in the process? This question forms the focus of the 'Living Rhine – river of a thousand islands' project by the Nature and Biodiversity Conservation Union of Germany (NABU).

Between 2001 and 2010, with funding from among others the Deutsche Bundesstiftung Umwelt (DBU), NABU experts initiated the revitalisation of around a dozen river bank regions between Iffezheim and the Dutch border. This involved breaking up paved banks and reconnecting shallow water zones to the river. A successful collaboration with the Federal Waterways and Shipping Administration, local authorities on the Rhine and other institutions has resulted in the return of more riverside land to its natural state over a length of around three kilometres in all. Here birds find new habitats, fish find spawning and feeding grounds, and the river can carve out its own banks according to the laws of nature. By 2015, with EU funding, side channels and shallow water zones will be created on the lower Rhine at Bislich and Emmerich. Both are valuable habitats for numerous animal species of the river and its floodplain. However, according to NABU's summary, the opportunities for the environment and the natural world are limited on heavily navigated waterways. Nevertheless, these opportunities must be exploited – even if they involve small areas and only alter the overall picture of the river very gradually.

As a means of transport ships have low transport costs, a large load capacity and produce significantly less noise and pollution than HGVs. However, shipping also has enormous negative impacts. In the process of regulating them to transport routes all the major rivers were so radically altered that they now bear little resemblance to the original water body. They were straightened, their banks reinforced, floodplains and branches cut off, shipping channels dredged and numerous obstructions erected across them. Today our major rivers actually resemble 'water highways' more than natural water bodies. That is why the Land authorities have classified many federal waterways as 'heavily modified water bodies' as stipulated in the European Water Framework Directive.

What was often neglected when river regulation took place was that rivers are not just transport routes for all kinds of goods, but are also migration routes for many species of fish. They link their habitats in the sea or lower river reaches with habitats and spawning grounds in upper reaches and tributaries. Herein lies the problem: around 340 obstructions, including more than 250 barrages, along federal waterways cut off the route for fish and other aquatic organisms. The result is that federal waterways are not 'passable' for fish and other organisms.

Moreover, these structures obstruct the natural water flow and the transport of sediment. When there is no sediment the river cuts deeper into the ground in some places, which can for instance cause the groundwater table in areas close to the river to fall. In long backwater areas at weirs, where the water only flows very slowly, substances such as those coming from agriculture or sewage treatment works accumulate. Last but not least, the straightening and regulation of rivers shorten the flow times of flood waves. If there are no floodplains or backwaters, there are no natural overflow areas for heavy rain and meltwater. This leads to steeper and higher tidal waves and to an increased risk of flooding.

On one hand government and industry cannot and will not do without inland shipping. On the other, European and German laws demand that waterways must be passable for organisms, that river regulation must not increase the risk of flooding and that no ecosystems are threatened or harmed by such regulation.

The amended Federal Water Act of 2010 contains for the first time provisions in federal law on the passability of dams. In accordance with this anyone constructing, altering or operating a dam is obliged to retain or restore the passability for migratory fish and sediment. The Federal Waterways Act stipulates that measures to regulate and maintain the waterways must be 'flood neutral'. The European Water Framework Directive sets a target for all rivers in Europe to reach a 'good ecological status' by 2015. As this is too short a timeframe for most member states, the Directive allows for an extension until 2027.

Some *Länder* have devised special measures for the federal waterways and agreed these with the owner, the Federal Waterways and Shipping Administration (WSV). However, the measures relate mainly to sections of rivers in which there is not much inland shipping. Nevertheless these are initial steps in the right direction. This is because everywhere that oxbows and side channels are reconnected to the main river, that solid river bank obstructions are removed and native scrub planted, animals and plants can recolonise and bring a small piece of nature back to the river.

Water protection always involves reconciling competing interests. Nowhere is that as evident as with inland shipping.

All major rivers should allow aquatic organisms unhindered passage.

Passable rivers are vital for a good aquatic environment. Although there are already about 130 fish ladders at barriers along the major German waterways, they have often failed to fulfil their function adequately, for example because they are too hard for migrating fish to find.

The Federal Ministry of Transport, Building and Urban Development (BMVBS) has therefore initiated a plan to ensure that all federal waterways will eventually again become passable for aquatic organisms. Because of its legal obligation the Federal Waterways and Shipping Administration is taking an active part in this. Previous scientific and technical assessments have shown that water organisms such as those in the Moselle, Danube and Neckar are severely hindered in their migration. In total on all federal waterways there are approximately 70 barrages with urgency level 1, meaning that they should be fitted urgently with modern migration aids.

Fish passes, fish ladders and other migration aids are not just an issue for river experts and engineers. They also represent a challenge for science, since upstream and downstream migration facilities must be suited to the water body, the current and above all the organisms present and be of the right dimensions for them. They can be constructed in a natural way in the shape of landscaped ramps, channels or ponds, or instead as concrete passes and ladders. That is why, as part of the BMVBS project, modern methods of analysis and simulation programmes are being used to study which populations are present in the water body, how the fish behave near large hydraulic structures and what currents occur above and below the structure.

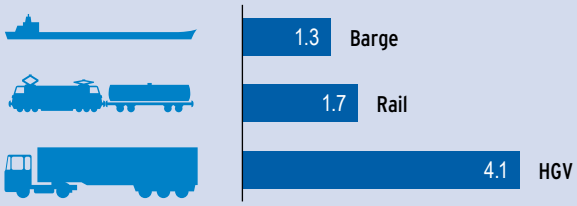
The underkeel clearance should be about a hand's width. The load must therefore be reduced during dry spells.

Shipping and climate change. Transporting goods via waterways makes a contribution to climate change mitigation, because ships can carry large tonnages and produce fewer emissions per tonne than heavy goods traffic, for example. However, conversely, climate change also has impacts on inland shipping, for example when as a result of global warming the risk of flooding increases or the water level in major rivers drops during prolonged dry spells. That is why, since 2009, the experts at the technical agencies of the Federal Transport Ministry have been studying the consequences of climate change for waterways and shipping in the KLIWAS project. On one hand the purpose is to maintain the efficiency of inland shipping, on the other water quality and habitats are to be protected. According to the initial results of the simulation calculations, the impacts of global warming will not be discernible in the large waterways in the short term. However, after 2070 the Rhine, for example, with its high volume of traffic and with a further increase in greenhouse gas emissions, could carry up to 30 percent more water in winter than in the comparable period from 1961 to 1990, but up to 25 percent less in summer.

Waterways are to be made passable for fish as well. A Herculean task for the government.

Primary energy requirement in goods transport

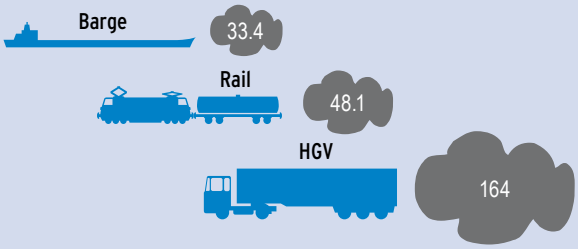
Litres of diesel per 100 tonne-kilometres



Source: IFEU – Institute for Energy and Environmental Research

CO_2 emissions from carrier

Grams per tonne-kilometre



Source: IFEU – Institute for Energy and Environmental Research

Many debates about river regulation for shipping end with the argument: what is more important – water protection or shipping? Disputes of this nature are unhelpful. Environmentally sound and climate-friendly shipping will have the right to use lakes and inland waterways in the future as well. The challenge consists more of highlighting solutions for sustainable use of federal waterways and trying to find a balance between ecology and the economy. It is the declared intention of the Federal Government to develop the use of waterways sustainably as part of transport policy. This presupposes that federal waterways can serve not only as efficient transport arteries, but also as diverse habitats.

Further reading:

- www.wsv.de
- www.binnenschiff.de
- www.lebendiger-rhein.de
- www.kliwas.de

CHAPTER 9: WATER WITHOUT BORDERS

Waters cross borders. The Rhine alone has a catchment area with 58 million inhabitants in nine states. The Elbe's catchment embraces 24 million people in four countries, and the Danube's as many as 80 million from 19 nations. Groundwater, too, from which many countries take large quantities of their drinking water, can stretch across national boundaries. Last but not least, many coastal waters in Europe extend from nation to nation.

For this reason water protection must also have a transboundary approach to planning, monitoring and action. Something that sounds rather abstract has impacts that repeatedly make headlines. If pollutants enter the water in the upper reaches of the Rhine in Switzerland, the river carries the substances into Germany, France and the Netherlands as well. If tributaries on the Polish side of the Oder thaw quickly in winter, the volumes of water rapidly flood into the marshland on the German side.

In some cases riparian states on major rivers already formed river basin associations many years ago. Germany is a member of ten such associations, six of which are larger international catchment areas: on the Danube, the Rhine, the Maas, the Ems, the Oder and the Elbe. At regular meetings representatives of Land and federal authorities as well as of other countries discuss issues concerning water protection. These include mainly pollution with hazardous substances or from agricultural discharges, and also questions on how to make rivers passable again for migratory fish. Environmental organisations, water users, research institutes and sometimes the interested public are also involved in these discussions. For the river basins purely within Germany, such as the Weser, there are committees where the German *Länder* work together.

The notion that such cooperation is essential to protect the waters also forms the guiding principle of the European Water Framework Directive. The European legislator has therefore set all member states the target of achievery 'good status' of water bodies, if possible by 2015. Rivers, lakes, coastal waters and ground-water should not only be contaminated as little as possible by chemicals, but should also be brought up to, and maintained in, a sound ecological status. The Water Framework Directive establishs a new perspective: with their catchments the waterbodies form an ecosystem that often crosses state borders. Furthermore, it addresses the fact that groundwater, surface water and floodplains interact – mostly out of sight. However, the Directive is setting a very ambitious time schedule with 2015. That is why most EU countries will take advantage of the exceptional rules that extend the deadline until 2027.

There is a tradition of cooperation between a number of riparian states on Europe's major rivers.

Reconciling different interests is a difficult task in transboundary water protection.

As water bodies do not keep to political boundaries, the Directive requires the EU member states to cooperate closely within the river basins. In doing this they should turn their attention to diverse and near-natural water structures, without preventing or severely restricting important economic uses. This is a difficult balancing act: rivers, lakes and coastal waters are used for a variety of economic activities. At the same time animals and plants rely on habitats which are directly dependent on water and which therefore need special protection. Reconciling different interests is therefore one of the most difficult tasks in transboundary water protection.

As different as the river basins are, there are bound to be problems with which almost all states have to wrestle more or less to the same extent, including for example, the high discharges of nitrate, phosphate and plant protection products from agriculture.

Besides these there are serious, but regionally limited sources of pollution. Mining is one example of this. In Germany this is mostly for brown coal, hard coal, potassium salt and rock salt. Mining can pollute surface waters and groundwater considerably during the exploitation of raw materials, and also for a long time afterwards. For example, to extract coal the water table must be lowered substantially. Even after mining has finished it takes very many years for the natural water table to be re-established.

The quality of water affects everyone. That is why it is important that the public is involved in the imple-

European rivers are put to a variety of uses. Shipping requires construction measures. Industry and settlements are edging up to the banks. Free spaces are used for farming, with little left over for nature and recreation.

mentation of the Water Framework Directive. The *Länder* have published their management plans and programmes of measures: how will a water body be used in future? What impacts will that have on the environment? What are the plans for improving the quality of the waters? In the course of this the Land authorities have exceeded the obligations of the Directive and have in recent years held intensive discussions about water protection issues with representatives of the public at round-table talks, regional events, in advisory councils and at other similar committees. There have also been public discussions at international level, e.g. in the Danube and Elbe catchment areas.

Germany has achieved a great deal for the protection of transboundary waters in the last few decades. In particular, as a result of the construction of municipal and industrial sewage treatment works, discharges of pollutants on the German side have fallen considerably. Not only do neighbouring countries such as the Netherlands benefit from this, but so do the coastal waters into which our rivers flow. Nevertheless, many of Germany's rivers, lakes and coastal waters are not in good status. This is shown by the monitoring programmes of the *Länder* based on the provisions of the Water Framework Directive. At a total of 8,500 measuring sites in surface water bodies and 11,000 groundwater sites tests were undertaken to find out how high the levels pollution are, whether pollutants and toxic substances are discharges, what biocoenoses occur and whether (for groundwater) there is a sufficient quantity of water.

Many of Germany's rivers, seas and coastal waters have poor ecological status.

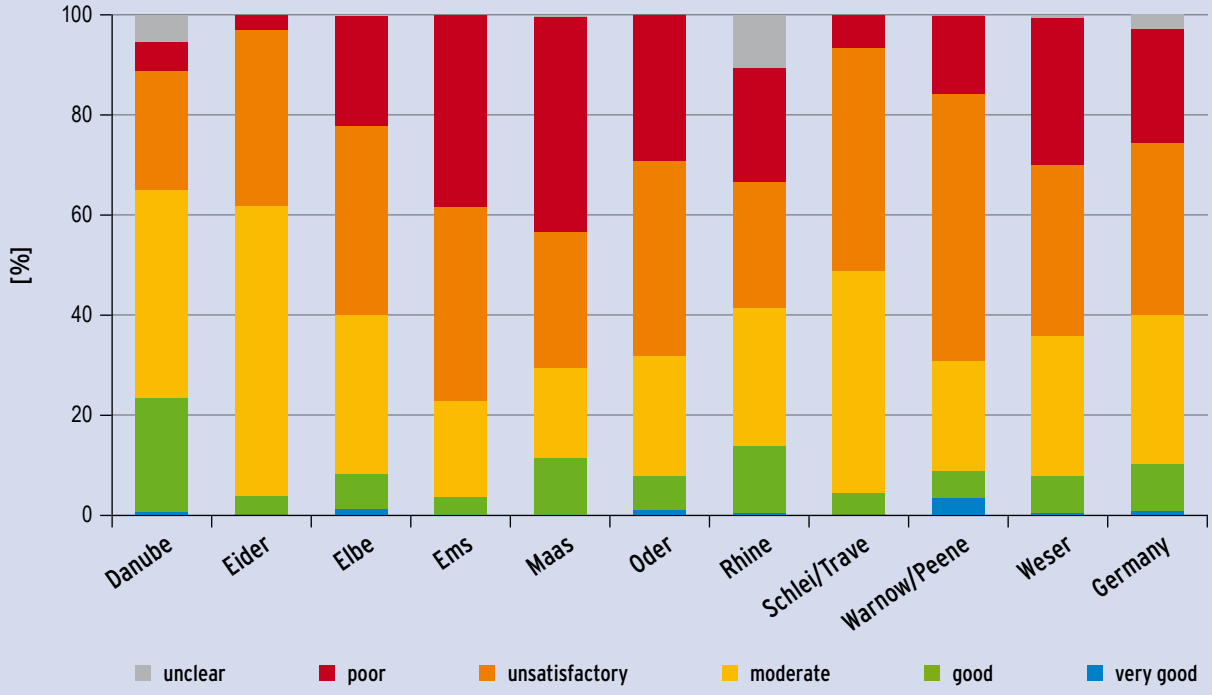
The results do not paint a particularly good picture of German waters – especially with regard to their ecological status. To date only ten percent have reached a good or high ecological status. Almost two thirds are classified as only moderate or poor. There are essentially two reasons for this: almost none of the rivers still has its original course with the natural flora and fauna. Moreover, the discharge of nutrients, especially from agriculture, remain high. These also threaten natural symbioses in the water. At first glance the situation for groundwater looks better, according to the analyses by the *Länder*. 96 percent of aquifers contain sufficient water, and so in the language of the Directive achieve a 'good quantitative status'. However, more than a third exhibit poor water quality and are severely polluted with chemicals – mainly owing to high nitrate discharge from intensively farmed land.

The Federal Water Act stipulates that a programme of measures must be produced for each river basin district to help improve the quality of the waters in future. This includes, for example, the extension of existing municipal and industrial sewage treatment works and the construction of new ones, the construction of stormwater retention basins and the renovation of old and leaking sewers. It also includes measures to reduce the pollution from agriculture – through cultivation methods that protect the soil or restrictions on the application of slurry and pesticides. These programmes of measures are currently being implemented. By 2015 18 percent of German rivers and streams should reach a good ecological status.

In all the basins river continuity has a special importance. In the major federal waterways alone there are around 340 dams that cut off the route for migrating fish. Dams and weirs cannot simply be demolished, as they are essential for shipping and hydropower. To open up the way for fish the authorities and operators are therefore concentrating on the construction of upstream and downstream fish migration facilities. These ensure that migratory species such as salmon and sea trout can reach their spawning and feeding grounds with minimal hindrance.

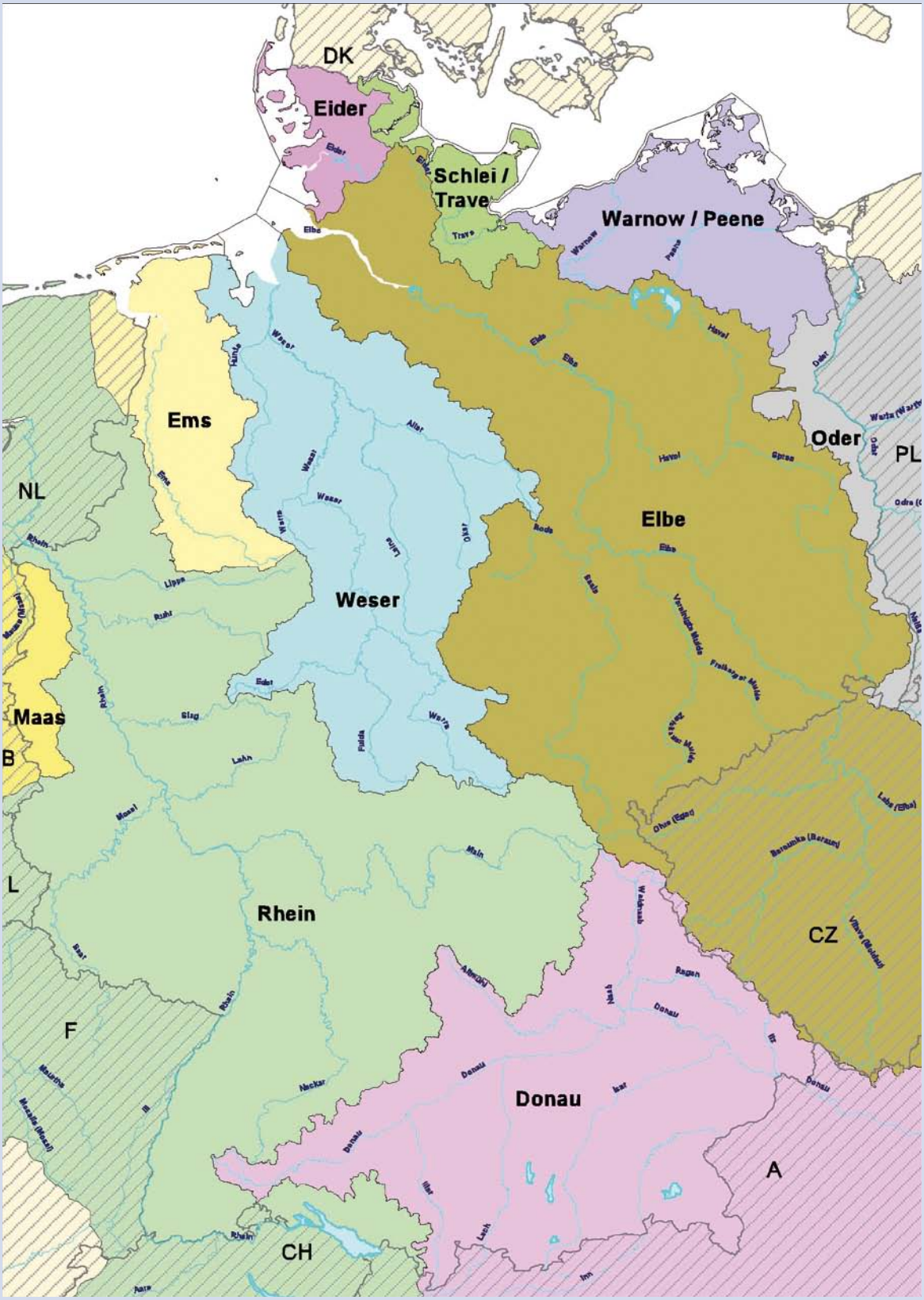
Nevertheless, despite all these measures only a few additional surface water bodies and aquifers in Germany are expected to achieve good status by 2015. There are various reasons for this: once substances have permeated into groundwater, they stay there for a long time, since groundwater flows very slowly and substance transfer processes in aquifers are equally

Ecological status of surface waters in the ten river basins relevant to Germany



Source: Berichtsportal Wasserblick/report portal of the Federal Institute of Hydrology, as at 22 March 2010

River basin districts in the Federal Republic of Germany
Directive 2000/60/EC – Water Framework Directive



The showing and labelling of parts of international river basins lying outside the borders of the Federal Republic of Germany is simply for illustration and have no bearing on stipulations of other states or international agreements.

Source: Federal Environment Agency, February 2002

A former weir was redesigned as a river bottom ramp. Now fish and other aquatic organisms can pass this stretch again.

slow. Secondly, sections of rivers that are restored do not recover overnight, but instead it takes time for plants and animals to recolonise in sufficient diversity and numbers. This all applies to the water bodies in other European states as well, which are faced with the same challenges as Germany.

Flooding is also a transboundary rather than a national hazard. The EU has passed a separate directive for flood prevention. It aims to help the member states to prevent or limit flooding and its negative impacts on human health as well as the environment, infrastructure and property by means of closer co-operation. It commits the member states to co-ordination in shared river basins and thus aligns flood prevention to hydrological or geographical rather than political boundaries.

Further reading:

- www.wasserblick.net
- www.iksr.org
- www.fgg-weser.de

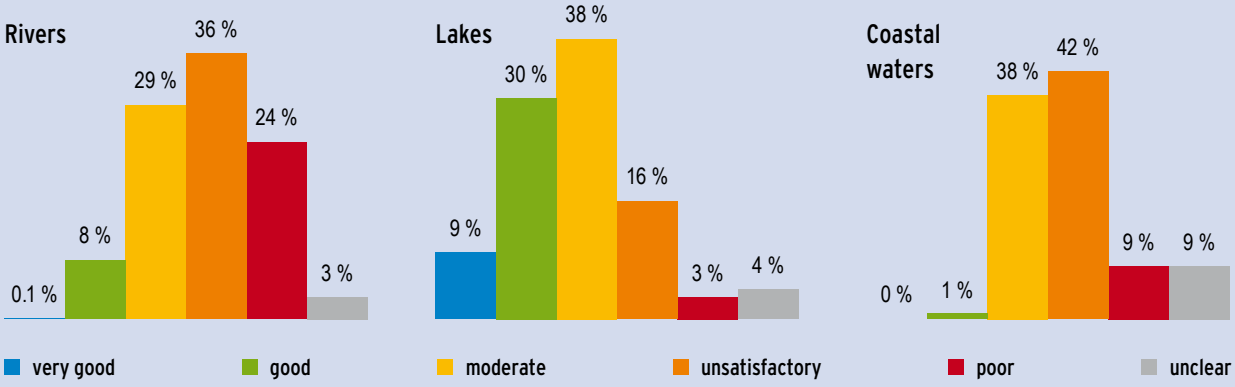
Fish migrate. During their life cycle salmon, sea trout, lamprey and many other species migrate from the sea to freshwater and vice versa. Weirs, hydro power plants and dams in the Rhine and its tributaries have destroyed or cut off spawning and nursery grounds of migratory fish. By means of its 'Master Plan Migratory Fish Rhine' the International Commission for the Protection of the Rhine (ICPR) aims to re-establish stable migratory fish populations in the Rhine catchment as far as the Basel area.

There have been initial successes. Since 1990 more than 6,200 adult salmon and almost 1,000 sea trout have been counted returning from the North Sea to their spawning waters in the tributaries. To achieve this, dams were fitted with bypass channels, weirs in the tributaries acquired fish passes and some obstructions were removed altogether. Recent studies show that almost all fish species previously occurring in the Rhine are again present – even if migratory fish are still relatively rare.

Making rivers passable again is expensive. Since 1990 the ICPR states have invested around 50 million euros. In order for the populations to become large enough to sustain themselves, an estimated further 100 to 150 million euros will have to be invested in the next few years. Continuity does not only benefit migratory fish; it also has a positive impact on the occurrence of many more plant and animal species and ensures a long-term improvement in the Rhine's overall ecology.

What happens after mining? When mines close the question of what should happen to the vast and radically altered landscapes often arises. Finding the right after-use for 'post-mining landscapes' is not straightforward: former opencast mines in the Lusatian and Central German regions are currently being transformed into an artificial lake landscape with 46 lakes and an area of water of around 25,000 hectares, intended as a nature resort to attract the crowds. For this the mines will have to be rapidly and constantly flooded with river water, which will however take a lot of water from the neighbouring rivers. In addition to this, the tailings piles often contain the sulphurous mineral pyrite, which reacts strongly with water. As a result the new lakes may exhibit extremely acid pH values of 2 to 4, which would preclude any use. However, the redesignation of former opencast mines has been successful in the Elbe river basin; in the last few years a great number of nature resorts and valuable refuges for rare plants and animals have been created there.

Ecological status of rivers, lakes and coastal waters in Germany



Source for all: WasserBLIcK/BfG (Federal Institute of Hydrology) report portal, last updated 2010.

Interview with Simon Henneberg,
Construction Engineer and Managing Director
of the Weser River Basin Commission

"The problem cannot be solved without cooperation"

Mr. Henneberg, what exactly is the problem on the Werra and the Weser?

For over a hundred years fertiliser salts have been mined in the area between Bad Salzungen and Gerstungen on the Werra. The rock extracted is processed with water to wash out the potassium and magnesium salts. In the course of this a total of around 14 million cubic metres of saline effluent is produced at three K+S sites every year.

How big a problem is it nowadays compared with previously?

Around a hundred years ago the people of Bremen noticed that their tea had an unpleasant taste because the water from the Weser was salty. In the Seventies and Eighties the Werra and Weser were saltier than the North Sea, because there were virtually no restrictions in East Germany. These high levels of pollution are a thing of the past. At the end of the 1990s the salt pollution in the river fell by around 90 percent, owing to a multi-million programme of funding from the state and the *Länder*. The processing methods have been updated and on top of that there have been plant closures.

How does the salt get into the water?

In the first instance via the direct discharge of production effluent. As well as this, rain also washes salt out of the tailings piles. A further amount, approximately a quarter, flows diffusely through the subsoil. For decades some of the effluent was injected to a depth of several hundred metres underground, because that was thought to be a safe method of disposal. Nowadays we know that some of the injected wastewater gets into the Werra via geological faults – amounting to around 14 kilos of chloride per second. That is why we are discussing whether injection can still be permitted in future: because in the worst case salt could get into the groundwater.

What does that mean for people and water bodies?

The main thing is that only plants and animals that can tolerate saline water can live in the stretches of the river affected. The region's drinking water does not come from the river. However, the people in the area have been aware of the problem for many years and are consequently very sensitive. When there were plans to build a 60 kilometre pipeline to the Werra to discharge effluent from the tailings piles, public pressure increased enormously.

Don't the authorities set any limit values?

There is a limit of 2,500 milligrams of chloride in the river. Although the value is the same as one set in the 1940s, you have to take into account that nowadays there is far less effluent per tonne of salt. The production processes are therefore much more effective than they used to be. And what is the point of setting a low limit value if there are no technologies that enable you to achieve it?

Are there no procedures that produce less saline effluent?

The K+S company is already doing some things to reduce the quantity of effluent. In the two plants in Hesse they process the salt dry, which means that less effluent is produced. At the Thuringian site the salt content of the effluent is lowered by means of a flotation procedure.

For the last two years there have been round table talks where K+S, authorities, experts and environmentalists have got together to try to find solutions. What has come out of those so far?

The Round Table is a huge step forward, because it has got all those involved talking to each other. All of them have discovered that there are no simple solutions to the salt problem. One important result is that the company is going to implement a range of measures to reduce the amount of effluent in the next few years, at a cost of around 360 million euros.

Could you give me an example of one of these measures?

A salt solution freezing system, which can extract more salt from the solution. Flotation is to be expanded. The use of dry processing will be stepped up and an evaporation facility to reduce the amount of effluent is planned. Altogether the chloride loading in the river should fall to 700 milligrams per litre, that is to say 30 percent below the present limit value.

The Round Table has proposed a large pipeline to the North Sea, to discharge the salt. What do you think of that?

The advantage would be that the effluent would no longer have to be pumped into the rivers. They could also dispose of some of the solids through the pipeline. However, a pipe of this sort is expensive and we must make sure that the Wadden Sea is not damaged. And a pipeline wouldn't make any difference to the diffuse inputs from underground.

How important is cooperation in the Weser River Basin Commission in addressing such a major problem?

The problem cannot be solved without cooperation. That applies to the Round Table and equally to the *Länder* in the Weser catchment. Talking to each other and exchanging ideas is a fundamental requirement for solving transboundary problems. What I notice is that perceptions are changing. Until the 1990s the geologists in the individual *Länder* still denied that wastewater injected underground could get through the rock and into the Werra. But we have to be patient, because perceptions don't change overnight.

CHAPTER 10: WATER IN THE SEA

Not long ago, the seas were regarded as habitats with endless resources, a virtually inexhaustible capacity for self-purification and, for us on land, as vast, rather alien and even menacing places. The sea often only penetrates our consciousness when there is a tanker disaster, when environmentalists are protesting against whaling or when, in holiday mood, we pack our swimming things.

And yet the sea has much more to do with our daily lives than many people think. Seas are transport routes for goods trade, they provide fish, seafood and algae, oil and gas, sand, gravel and mineral salts. The seas are even more important for the vital functions of the earth: they are the lungs, heat pump and air-conditioning unit all in one and form the basis for the global cycles of energy, water, oxygen and carbon dioxide. The oceans make up the earth's largest interconnected ecosystems and hold the major share in the biosphere on our planet. Our 'home waters' are the North Sea with the especially valuable ecology of the Wadden Sea and the Baltic Sea with its fragile bodden.

Almost everything we do and the way we do it impacts on the function of the seas.

The oceans are among the habitats on earth which are intensively exploited but inadequately protected.

According to figures from the Food and Agriculture Organization (FAO),] around 4.5 billion people worldwide rely on fish to cover 15 percent of their protein requirements, 1.5 billion even cover 20 percent with fish; most of them live in the poorest countries of the world. Today around 32 percent of global fish stocks are already overfished, and even 63 percent in European waters. Coastal waters suffer from overfertilisation owing to discharges from agriculture and from discharges of hazardous substances from industry, shipping pollutes the seas with oil and waste, and hazardous substances can escape from offshore oil and gas rigs. Underwater noise from engines, drilling platforms, dredgers and the erection of offshore wind farms is a still largely unresearched type of pollution particularly affecting marine mammals.

However, marine conservation is not a simple matter, as seas do not recognise national boundaries. Conservation programmes are therefore only likely to succeed on the basis of transnational, i.e. regional, European or international agreements. There is no point in going it alone. For example, in Germany 97 percent of the population is connected to modern sewage treatment plants, but until all the littoral states on the North and Baltic Seas have a similarly high level of connection, the efforts to treat German wastewater are no more than a clean drop in the ocean. Besides: seas are used by many industrial sectors and none of these would accept deep cuts in their use. Last but not least, not all littoral states are equally sympathetic to marine conservation.

As early as the 1970s there were initial international agreements to limit the pollution of the North Sea, Baltic Sea and Mediterranean. Today the list of conventions, programmes, action plans and individual projects is as long as the list of dangers threatening the seas. This is an indication that more and more nations recognise the importance of marine conservation, not only to climate change mitigation and the environment, but also to economic survival.

The basis of many agreements is the 1982 Convention on the Law of the Sea. Germany has been involved for many years in global and regional marine cooperation and is an important driving force in ensuring that the goals enacted therein are regularly revised and tightened up. Three of the most significant international cooperation agreements are the International Convention for the Prevention of Pollution from Ships (MARPOL,1978), the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR,1992) and the equivalent for the Baltic Sea area (Helsinki Convention,1992).

These conventions can certainly register some successes. Incineration and dumping of industrial waste at sea has been banned, and inputs of heavy metals, pesticides and plant nutrients via rivers have fallen significantly since the 1990s. Since July 2010 ships using the North and Baltic Seas may only burn low-sulphur heavy fuel oil. In September 2010 the members of the OSPAR Convention designated the world's first network of marine protected areas in international waters. With this the extent of the marine reserves in the North-East Atlantic to which threatened animal species can retreat has been increased to 433,000 square kilometres – equivalent in size to the entire Baltic Sea.

Of great importance for Germany is the protection of the Wadden Sea, which has been a UNESCO world heritage site since 2009. Inclusion in the UNESCO list makes it clear that the Wadden Sea is a globally unique and irreplaceable nature reserve. The area, which covers almost 10,000 square kilometres, stretches for around 400 kilometres along the coasts of Denmark, the Netherlands and Germany. These three countries have already been working together for about 30 years to protect this ecosystem. In the new Wadden Sea Plan 2010 they intend to take joint responsibility for ensuring that the Wadden Sea is preserved as a unique ecosystem and that at the same time productive uses by fisheries, tourism and farming industries are still possible in future.

The efforts made and successes achieved so far are not enough for sustainable management of our seas. It is essential to restore the balance between conservation and use.

Endless horizons – and yet our oceans are threatened

Good status of the seas – what does that actually mean? A long list of criteria is attached to this 'good status': safeguarding habitats for native species, preserving fish stocks, minimising discharges of pollutants to the seas, protecting ecosystems on the sea bed, complying with limit values for contaminants in seafood and preventing harm to coastal and marine environments from waste and noise.

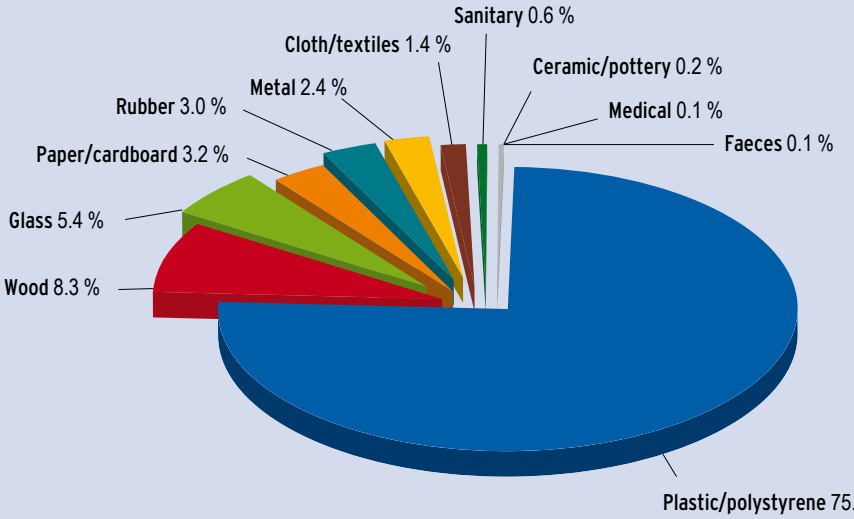
If raw materials, energy and food are harvested from the sea, it must be done in such a way that the marine and coastal environments are not polluted, finite resources are conserved and ecosystems and fish stocks can regenerate sustainably by themselves. In its National Marine Strategy the Federal Government establishes the goal of preserving or restoring a good status of the marine environment in the North and Baltic Seas by 2020. By 2015 the waters in the one-mile zone should be brought up to a good ecological status, while the coastal waters in the 12-mile zone should come up to a good chemical status.

We must not live 'on tick' as far as the seas are concerned, but must manage things in such a way that future generations will also have healthy seas with resources they can rely on. That is also the fundamental idea behind the Marine Strategy Framework Directive agreed by the EU member states in 2008. It is the environmental environmental pillar of integrated European maritime policy and aims to achieve a 'good status' in the Baltic Sea, the North-East Atlantic, the Mediterranean and the Black Sea by 2020, i.e. to protect the marine ecosystems and minimise the discharge of pollutants and waste into the seas. From then on no waste in the sea may have damaging impacts on the coastal and marine environments. However, as yet there has been no comprehensive scientific research, such as on the question of the negative ecological impacts of waste or how badly river estuaries, coasts, the surface of the sea and the deep sea environment are already polluted. Nor are there yet any effective strategies or patent remedies for preventing further dumping of waste in the sea.

Germany has transposed the EU Framework Directive in German law by amending the Federal Water Act. Thus regulations on marine waters outside coastal waters are now included in the Act.

The seas deserve more consideration, not least in terms of policy. Marine conservation is much more than the preservation of fish populations or a ban on throwing waste overboard, because the oceans are

Common types of beach litter



Source: Based on Marine Litter – Technical Recommendations for the Implementation of MSFD Requirements, Joint Research Centre (JRC) of the European Commission (2011, in preparation)

Beach litter

the focus of many different economic interests. That is why marine conservation has a direct influence on other policy areas such as agriculture, fisheries, shipping, climate change mitigation and the chemicals policy and must be far more closely integrated into these areas.

But seas also deserve respect and attention from every one of us, because our daily consumption of foodstuffs, resources and energy generates large quantities of emissions, greenhouse gases, pollutants and wastewater. Much of this is flushed into the oceans or disturbs the natural functions of the seas, which we must recognise – despite their vast proportions – as sensitive ecosystems.

What is plastic waste doing in the sea? Anyone who has been following the news in recent months will recognise the headlines: the millions of tonnes of waste that end up in the oceans every year – three quarters of it plastic – have become a hazard to marine organisms. Birds, fish and other creatures eat plastic items and die in agony with filled stomachs or from internal injuries. There is documentary evidence that 40 percent of all whale species, approximately 36 percent of seabirds, all sea turtles and many species of fish ingest waste orally. It is known that 136 marine species regularly become entangled in discarded or lost nets, ropes and other waste and suffocate. Especially dangerous is that breakers and waves pound plastic waste into microparticles which absorb toxic pollutants. These microparticles are eaten and can reach humans as well via the food chain.

The origin of the waste varies. For example, whereas in the Mediterranean around 80 percent of waste comes from land – it enters the sea via rivers and wastewater or is blown off beaches and dumps near the coast by the wind – in the German North Sea the bulk of the waste probably comes from shipping, with a substantial proportion from the fishing industry.

Marine litter is no longer just an issue for environmentalists and nature conservationists; the plastics industry has become aware of the problem as well. In March 2011, 47 industry associations from 29 nations signed an international declaration in which they commit themselves to supporting such measures as plastic waste recycling, modern waste disposal and research into the issue of marine litter. The German plastics industry is currently funding two scientific studies that are to report by 2012 on the ways in which plastic waste enters the Mediterranean and the North and Baltic Seas, and what countermeasures would be appropriate.

Interview with Professor Klaus Töpfer, former Federal Environment Minister, now Executive Director of the Institute for Advanced Sustainability Studies in Potsdam

"Sometimes I get very angry"

Professor Töpfer, what is currently the greatest threat to the oceans?

Billions of people depend on fisheries for their food, but indiscriminate fisheries has led to a situation where there are wide areas with virtually no fish left. Another point is that we are taking out more and more raw materials, gas and oil from deeper and deeper parts of the sea – with huge environmental risks, as the accident on the Deepwater Horizon platform in the Gulf of Mexico showed. Plus, of course, the increasing littering of the seas. Every year 6.4 million tonnes of waste end up in the oceans. That is shocking.

Each one of these dangers is big enough on its own. Is there any chance left of rescuing the oceans?

I refuse just to let things go on as they are. No problem has ever been solved by giving up. After all, there are definitely successes to report. I'm thinking of the world's first protected areas on the High Seas set up by the OSPAR Commission states in the North-East Atlantic, and the global agreements as part of the Convention on Biological Diversity. Those are hopeful signs.

There are numerous international conventions on marine protection. So why is it still happening so slowly?

The economic pressure is enormous. What makes it even more difficult is that the oceans are viewed as common property. They don't belong to anyone and because they don't belong to anyone, no one really bothers about them. Moreover, we work in a too sectoral way in marine policy: some people deal with fisheries, others with nature conservation or marine mining. We have to combine these more effectively at policy level in order to make progress. At EU level we now have the Marine Strategy Framework Directive for an integrated approach of this sort. It is now time to implement it comprehensively and for all sectors.

Do you get annoyed that economic interests often take precedence over sustainability and protection?

I do sometimes get very angry, but being angry stops you thinking constructively. When I was Executive Director of the UN environment programme in Nairobi I saw how the people's food resources were systematically destroyed by poaching off the coasts of African countries. Getting cross about it doesn't help matters. We have to get the people onto our side and promote awareness of how important the seas are for food, the climate, species diversity and our survival.

Should we use bans to restrict the economic exploitation of the oceans?

Every designated marine protected area is essentially a restriction on economic use, and a restriction like this can make twice as much sense. It protects the seas and marine organisms, yet it is also very beneficial economically. In protected areas the fish stocks are able to recover astonishingly quickly. That is exactly what sustainability is: using resources in such a way that we safeguard our livelihoods in the long term. It sounds easy, but in fact it's extremely difficult. I'm afraid that's because we mostly bow to short-term demands.

What can Germany do?

Germany is playing an important part by driving many developments forward. The Federal Government is committed to the regional marine protection conventions for the North-East Atlantic and the Baltic Sea as well as for the protection of the Wadden Sea. Urgent reform of the common fisheries policy is the next priority in the EU, so we have to continue to be actively involved.

What is your institute doing to help the seas?

We are researching the components of the earth system, climate change and sustainability. That is why marine protection is an important subject for us. We are working with our partners to address the question of how international cooperation can be improved. We are also studying the impacts of human activity, especially in coastal zones near very large cities. In these areas there are often so many pollutants and so much waste washed into the water that 'dead zones' are created, where all life is extinguished.

What can ordinary people do to protect the seas?

Policies need pressure from the people. Environmental and nature conservation associations have an important role in marine protection. Think of the campaigns against whaling or marine dumping, which are very effective. People who eat fish should make sure when buying that it comes from sustainable fisheries; for example, the Marine Stewardship Council label will tell you that. And sometimes marine protection is quite simple: taking disposable packaging to the beach and leaving it there is not good for the seas.

CHAPTER 11: WATER AND CLIMATE CHANGE

Flooding cannot be banned. What we can do is to take precautions and limit the damage potential.

Every year we burn vast quantities of coal, oil, petrol and gas – in power plants, industrial installations, motors and engines and in the boiler in the cellar. As a result emissions of carbon dioxide and other greenhouse gases have increased significantly in the last hundred years. Carbon dioxide in the atmosphere reflects the thermal radiation from the earth's surface, resulting in a rise in the global average temperature of the earth.

Is the climate changing or not – that question is no longer relevant. Since the beginning of the 20th century the global average annual temperature has risen by a good 0.7 °C. In Germany the increase was as much as 0.9 °C. To the lay person that does not sound much, but in terms of global climate events these are dramatic leaps, which have consequences: a comparison of data from the German Meteorological Service shows that between 1980 and 2009 there were significantly fewer days of rain in summer in Germany than in the years from 1951 to 1980. By contrast the number of 'heavy rain events' in winter, particularly in the lower mountain ranges, rose to up to eight per decade.

What can we expect in the coming decades? Global climate change will intensify. How, where and how severely it will affect Germany, nobody can yet predict precisely. That is because the impacts will vary according to region and season. Experts are expecting that in general winters will be warmer and summers hotter. There will be more and longer dry spells. In the Alps glaciers will melt and snow cover will become thinner.

These predictions make it clear: human-induced global warming impacts above all on the water cycle, because the higher the temperature in the atmosphere becomes, the more water can evaporate and fall again as rain. However, it will not fall everywhere. In some parts of the world heavy rains, high tides and flooding will increase, while in other countries droughts and dry periods will worsen. Furthermore, high temperatures accelerate the melting of the polar ice caps and so sea levels rise. Thirdly, if sea water heats up owing to rising air temperatures, there will be a change in ocean circulation patterns and the conditions for aquatic plants and animals.

The earth's climate will continue to warm up even if we succeed in halting emissions of greenhouse gases at once, because we will only begin to see the consequences of the emissions of previous years in the coming decades. That is why more and more countries are worrying about how to prepare for the impacts; for example, how to adapt their farming methods, improve flood protection and reduce water consumption.

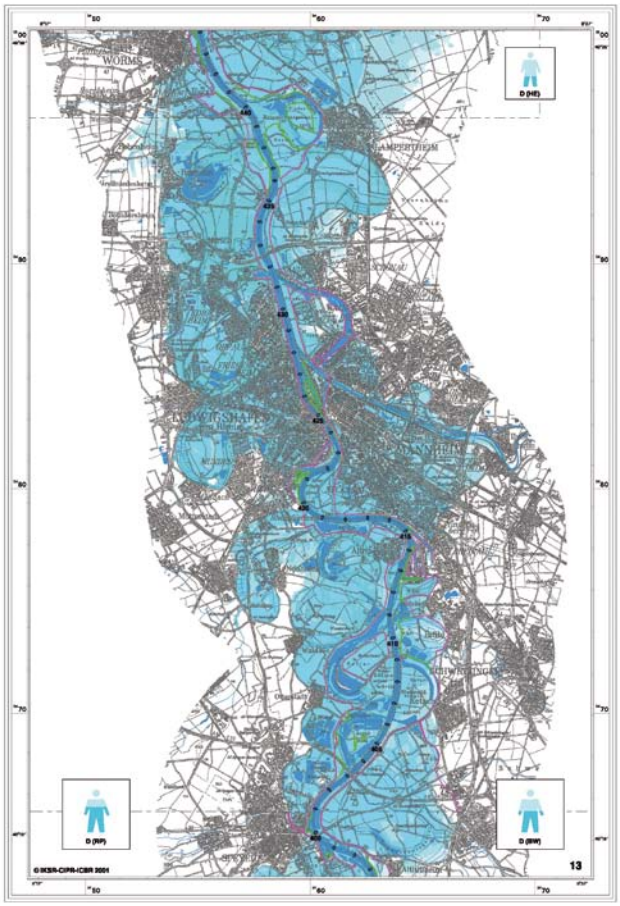
Consequences are also looming for Germany: as heavy rains and floods may wash pesticides, fertilisers, industrial chemicals and pathogens into groundwater and surface waters, their quality could deteriorate. If rivers and lakes warm up, their oxygen content falls. This creates stress for animals and plants living in them. Moreover, pollutants that were previously bound to sediment dissolve more easily in warmer water.

In some regions of Germany occasional shortages of drinking water could occur: if there is less rain, less groundwater can form. It may also be that it will be more difficult to process water from rivers and groundwater into clean drinking water. The central and eastern regions of East Germany could suffer particularly from dry summers. The northeast could even fall below the critical level of 400 millimetres of precipitation a year – that is real drought stress for many cultivated crops. That is why adequate water storage in reservoirs will be important in future, and where possible long-distance pipelines to compensate for drinking water shortages. Agriculture and forestry will have to adapt to the possibility of less available water by using drought tolerant species of plants and trees and water-saving sprinkler systems.

As it will rain more frequently and more heavily in Germany in the winter, the risk of flooding will increase, especially in the spring. This is particularly critical for Germany as a densely populated and intensively farmed country. In Germany people have always lived near rivers; that is why almost all well-known cities are built by the water. The great floods on the Elbe, Rhine and Oder in the last ten years have made it clear that inundations do not only harm ecosystems, but also cause billions of euros' worth of economic damage – a cost that has to be borne by society as a whole.

There have always been floods, but climate change makes a risk that people have lived with for centuries into a serious and frequently recurring threat to the environment, nature and society.

Flood risk on the Rhine



Source: ICPR – Atlas of flood danger and potential damage due to extreme floods of the Rhine, 2001

For that reason flood prevention has a high priority in Germany. The main political instrument is the Flood Control Act passed after the great floods on the Elbe in 2002. It stipulates for example that the authorities must include information on floodplains in all land use and development plans by 2012 at the latest. There must be flood retention zones in these areas, the conversion of grassland to cropland is prohibited and the designation of land for new developments severely restricted. Furthermore, the Flood Control Act defines 'flood risk areas', i.e. land that could also be flooded if dams burst or dykes are breached. The authorities must produce hazard and risk maps for these areas, so that in future residents will be able to find out about the flood risk in a certain area with greater ease and accuracy.

Although climate change is talked about almost constantly, so far industry in Germany has done little to prepare for it. Waterworks have not been adapted to longer dry periods in the summer. The energy sector – the largest water user in industry – should be developing cooling systems that can operate on less water. As yet farming seldom uses cultivation methods that improve the soil's water retention. The impacts of climate change are scarcely considered in development plans, and awareness of the risks among the population in general is also somewhat limited. People often underestimate the extent to which they are at risk from flooding, and many homeowners rely explicitly or unconsciously on state assistance in an emergency.

In 2008 the Federal Cabinet passed a German Strategy for Adaptation to Climate Change. It describes the impacts of climate change and the options for adaptation for 13 areas of life, the environment and industry – including water resources management

Climate change is a concern for everyone, because it will be felt in all areas of life.

and coastal protection. The strategy aims to make society, industry and the environment better able to withstand changes in the climate and their consequences and to prevent those consequences taking us unawares.

A noble aim, since conflicts of interest are inevitable. For example, who will have access to water in future, if there really are summer shortages? It is also very difficult to prepare for consequences that even experienced climate scientists can only sketch out

Pupils at an information booth on flood risk management. It is never to early to learn about precautionary measures

Climate change at local level. Many German *Länder* have started to record and analyse the regional changes. Bavaria, Baden-Württemberg and the Rhineland Palatinate are cooperating on the KLIWA project to research how temperature, precipitation, heavy rains and the number of floods have altered in the last eighty years. The findings: the impacts of global climate change have already been felt in southern Germany for some time and in some cases have clearly intensified since the year 2000. Between 1931 and 2005 the average annual temperature rose by 1 to 1.3 degrees in winter and by 0.7 to 1.1 degrees in summer depending on the region; that means more precipitations in winter and longer hot dry spells in summer. In Bavaria in particular the number of floods rose significantly over the years.

Climate models show that climate change could affect the north of Germany differently from the south, and the west differently from the east. However, the climate monitoring in southern Germany also showed that the impacts can vary widely even within a single Land. For example, in the case of heavy rains the increase in north-east Bavaria alone varied between five and forty percent.

Buildings and flood risk. The best flood protection is not to build at all in floodplains or flood risk areas, but in practice it cannot always be avoided. For that reason architects and engineers are now trying to come up with potential designs for flood-proof buildings. For example, oil heating systems would not be used, or the boiler would be installed on the top floor instead of the cellar, so minimising the risk of heating oil leaks. Another possibility is to build without basements, by putting the house on stilts. Doors and windows can be fitted with movable walls to prevent water penetration, and water-resistant building materials for walls and floor coverings can also help.

Meanwhile, the first 'floating' houses have been built in the Netherlands which, owing to flexible water and wastewater pipes and a special construction method, can adapt to the water level. The houses sit on a watertight concrete cubes which give buoyancy in the event of flooding. As the water rises, the buildings are raised up, with vertical poles ensuring that they remain in position.

roughly and in general terms. Many people wonder why we have to take action now if the effects will not be apparent for decades.

What makes things more difficult is that adaptation only functions through cooperation – of national and Land authorities, different industrial sectors, industry associations, science and the general public. In August 2011 the Federal Cabinet agreed the Adaptation Action Plan. This aims firstly to advance research to obtain more reliable evidence on the consequences of climate change in Germany, and secondly to ensure that all plans and projects, whether carried out by private individuals, businesses or authorities, are checked to see that they are climate-friendly.

One thing is clear: we will no longer be able to organise our everyday activities on the basis of a stable environmental situation, as we have until now. Instead we must prepare ourselves for wider variations in the weather, more extremes of precipitation and temperature and perhaps even times of scarcity and supply problems.

Further reading:
- www.anpassung.net
- www.kliwa.de

The Elbe river at Dresden at average flow. The flood of 2002 reached a historic height of 9.40 m on 17 August.

Interview with Nobel Prize winner and climate scientist Professor Martin Beniston

"I'm afraid that we are not acting fast enough"

Professor Beniston, you are working on the impacts of climate change on the Alps at the University of Geneva. Why specifically the Alps?

You can see the effects of global warming particularly clearly in high mountain regions. The alpine glaciers have lost 20 to 30 percent of their mass since the 1980s. In the hot summer of 2003 alone ten percent of the ice in some glaciers melted in just a few weeks. By the end of this century 50 to 90 percent of the glaciers could have disappeared.

What does that mean?

Since the winters keep getting warmer, the ice and snow in the Alps melts earlier and to a greater extent. This results in more flooding along rivers like the Rhine and Rhone. In summer, on the other hand, the mountain regions will not be able to provide as much water, because there will then be only a few glaciers left. Less water for the rivers will create problems for power plants and for agriculture.

Can we actually believe what the supercomputers calculate?

Computers only provide figures which then have to be interpreted by climate experts. The different models that we use nowadays generally come to different conclusions. One model predicts ten percent more rain in winter, while another will say 40 percent. Whether or not you believe these figures is up to you. What is crucial is that all the climate models predict the same trends: longer dry periods in summer, warmer wetter winters and slowly but surely rising average temperatures.

People want to know exactly how the climate is going to change in their own regions. In this respect the models are extremely inaccurate.

The regional models have improved considerably in the last five or six years. However, that doesn't alter the fact that climate models are only as good as the data fed into the computers. There is almost nothing

in the world more complex than the climate. Thousands of physical data have to be entered, on top of which scientists have to make assumptions about how greenhouse gas emissions will alter in the coming decades. But who can know that for sure? A third aspect is the element of chaos. Even when we have all the data correct, there will still be influences that even experts can't predict.

What are the effects on the water balance that worry you particularly?

It is disastrous that major rivers could dry up almost entirely in summer after 2050. In the summer of 2003 the water in the Rhine at Cologne and Bonn was already extremely low. If the temperature of rivers and lakes rises, germs will grow much more rapidly than in cool water. I see this as another danger for a number of regions.

We can't eliminate climate change, but we can be prepared. Are the government and industry doing enough towards adaptation?

There are a lot of small projects: care homes for the elderly are being fitted with air conditioning, companies are changing their production methods to save water and energy, and supermarkets are putting locally or sustainably produced goods on the shelves. In southern Spain they are building the first desalination plants so that they can cope better with periods of drought. These may only be small steps, but they show that perceptions are changing.

Don't we need large steps to prepare for climate change?

Yes, of course. There are some really interesting initiatives in some European cities, such as the 2000-Watt Society. The idea is that each individual uses no more than 2000 watts of energy in a year; that's less than now by a factor of five. And there are companies, including big corporations, which recognise that they can turn good profits and become more competitive by using climate-friendly technologies. I see that as an important incentive: those who conserve resources and reduce their emissions can profit economically. Nevertheless, I'm afraid that we are not acting fast enough.

Why are we so slow to react?

It is human nature to react immediately to environmental disasters and sudden changes, but we are reluctant to respond to changes that take place over many decades. If in the future we get extreme summers like 2003 in quick succession we will all wake up to climate change. We have to realise that everything that we do now to protect the climate will only take effect in many years' time. Unfortunately, there are no easy answers and no patent remedy. The point is that the longer we wait, the more extreme the impacts of climate change will be and the more it will cost us to deal with the consequences.

CHAPTER 12: WATER WORLDWIDE

We in Central Europe can expect our water to be clean. In that respect we are living in the lap of luxury, as for billions of people in the world safe drinking water, basic sanitary facilities and regulated sewage disposal are still no more than a dream.

In the Millennium Goals the United Nations declared the fight against the water crisis to be one of the top priorities of development assistance.

Purely on the basis of numbers there would be enough water for everyone. So much precipitation falls on the land surface every year that each of the almost seven billion people on earth has around 5,700 cubic metres available annually. That is enough to fill a tank 50 metres wide, 60 metres long and 1.9 metres deep.

However, precipitation is very unfairly distributed from a global point of view. Large sections of humanity live in water-poor regions and have to make do with 500 to 1,000 cubic metres a year. The water requirement of around two cubic metres a year for drinking and cooking is the least of the problems, as people also need water to wash, to irrigate the fields, to manufacture goods and to cool power plants. In the course of many of these processes large quantities of polluted wastewater is produced. Treating dirty water in such a way that it can be returned harmlessly to the natural water cycle is one of the most important tasks of modern civilisation and therefore one of the most pressing tasks for development assistance.

In 2000 the United Nations declared the fight against the water crisis to be one of the most important issues for humanity. In the UN Millennium Goals they set the goal of halving the number of people without access to clean drinking water by 2015 compared with 1990. The provision of simple sanitary installations, sewers and treatment plants is also to be improved markedly by 2015. In 2010 the United Nations even accorded access to clean drinking water and

Owing to the long distances, many children spend whole days fetching water, to the detriment of their education.

Conflicts over water

Conflicts over use on international watercourses

Source: Federal Agency for Civic Education

basic sanitation the status of a human right, because water is also the key to other important Millennium Goals; without water there can be no food and therefore no reduction in poverty in the world.

In some regions of the world there has indeed been progress. According to the UN around 1.8 billion more people have access to clean drinking water now than in 1990. Nevertheless a lack of water or polluted sources are still the key cause of poverty, malnutrition and disease. Several thousand children die every day as a result of unclean drinking water. One in five people in the world still does not have clean water for drinking and cooking, and one in three even lives without any sanitation.

The outlook is anything but good. Population growth, agricultural expansion and intensification and economic development have led to a global increase in the pollution of water resources with harmful substances. Climate change threatens to exacerbate the water crisis in some regions of the world, because precipitation shifts geographically as a result of global warming and people in dry regions have to make do with even less water. Globalisation also contributes to the water crisis: because a lot of companies from industrial countries have their goods manufactured in countries with low wage levels, many production processes that use water intensively or put water supplies at risk have been relocated to developing countries and emerging economies during recent years, which makes the pollution of local water resources even worse.

Moreover, experts warn of a social development that further aggravates the problem: more and more people in developing countries and emerging economies are drawn to cities and conurbations, where they hope for better living standards. In these megacities such as Mexico City, Mumbai, Buenos Aires, Cairo and Dhaka, with ten to thirty million people, the water problems are concentrated to an extreme extent. The situation today in many megacities is already perilous and in many cases intolerable, the WWF warned at the World Water Week in August 2011.

It is expected that, by 2050, 70 percent of humanity will live in megacities. This will exacerbate water problems dramatically.

This much is clear: using water economically, intelligently and sustainably is of great importance for many people's future. That is why the EU countries are focussing their development assistance on water problems. Owing to the support of the European Commission more than 32 million people have gained access to a better drinking water supply and 9.5 million to sanitation since 2004.

Germany is involved in cooperation in international river basins and in bilateral cooperation with individual countries on issues of water pollution control, sewage treatment and flood management, focussing on eastern and south-eastern Europe. Germany enjoys an excellent global reputation in the lead market for sustainable water management, with its high-quality products and expertise. Germany has an 18 percent market share of the global trade in water resources management products. The global water market has an estimated volume of up to 500 billion euros. Owing to increasing demand for water a growth rate of six percent is anticipated in the next four years alone. That is not just for drinking water and wastewater treatment systems, but also for efficient irrigation technologies, desalination plants, technical equipment and filtration systems.

Germany is also one of the largest donors in the water sector. Projects to improve supply have been a key focus of German development cooperation for many years. Germany has many years' experience in water resources management in both the public and private sectors and has a dense network of research institutions and a multitude of competent companies in the water sector.

In 2008, in order to pass on this knowledge more effectively in regions with major water problems, businesses, associations and research institutions from the water industry founded the German Water Partnership with the support of several federal ministries, including the Environment Ministry. It unites around 300 private and public sector companies, engineering firms, research establishments, professional associations and institutions connected with the German water industry (see also interview).

The experiences from development cooperation in recent years show that technology alone cannot solve the water crisis, not least because water is a political issue.

Firstly at national level: development cooperation can only bear fruit once the governments of developing countries and emerging economies perceive the problems and create institutions that can manage water resources efficiently. Secondly at international level: there are more than 260 transboundary river basins worldwide. This means that managing water resources and water bodies is inconceivable in many

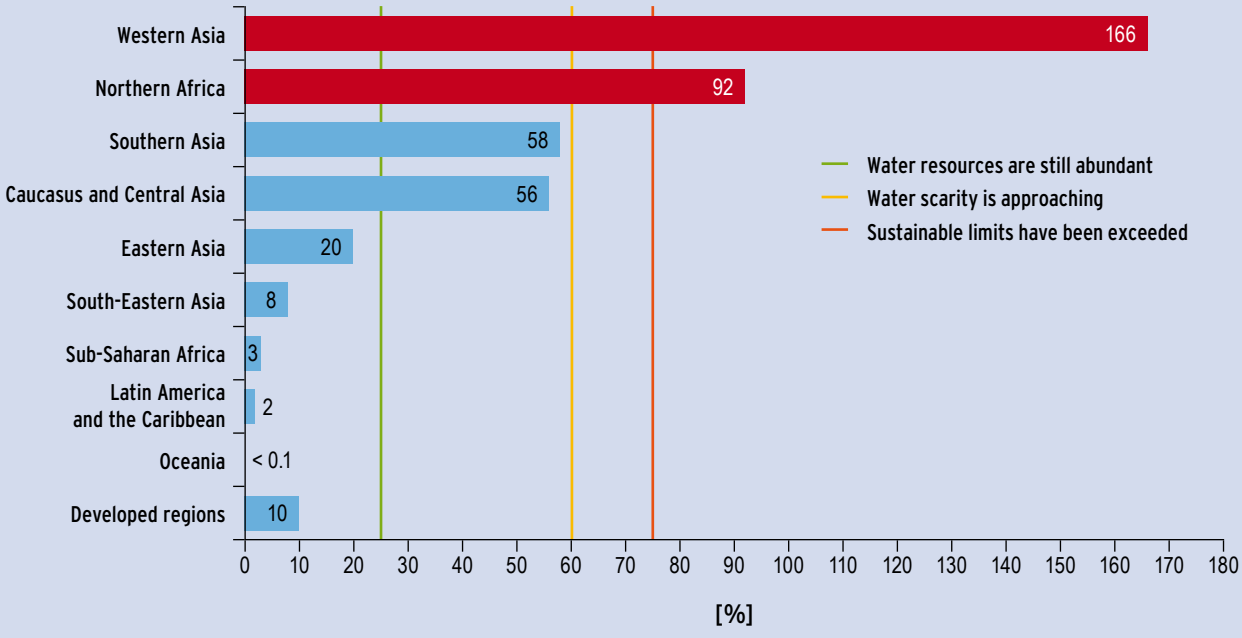
cases without international cooperation. However, it also means that disputes and even armed conflicts can occur over water. That is why the promotion of transboundary cooperation is not only the key to conserving resources and combating poverty, but at the same time actively prevents crises and conflicts.

Further reading:

- www.worldwaterweek.org
- www.germanwaterpartnership.com
- www.wwf.de/themen/suesswasser/
- www.bmu.de/binnengewaesser/aktuell/3795.php

Water stress in Asia and Africa

Surface water and groundwater withdrawal as a percentage of internal renewable water resources, taking into consideration official treaties between countries, around 2005



Source: UN Millennium Development Goals Report 2011

Interview with Stefan Girod,
General Manager of the German Water Partnership

"We must make people realise the value of water"

Mr. Girod, why are water companies important for development assistance?

Hold on – we're talking about development cooperation, not development assistance. The message is in the word: for successful projects we need the cooperation of all participants. Government has an important role in this, but so has the involvement of the companies. We have to work together to achieve a situation where the countries in which we are active take over responsibility for water management and the use of their limited resources. That is because sustainable water resources management is fundamental to all economic development. For many countries in the world there is almost nothing more important.

Why does it need an organisation like German Water Partnership?

In Germany we have a high degree of specialisation among companies in the water sector, extensive expertise in local authorities, and a lot of knowledge in numerous universities and research institutes. But precisely because the competences are so widely distributed it makes sense to combine research, industry and associations. This should put us in a position to provide everything from a single source, from advice on planning and construction, through funding to the operation of plants and training of personnel. It is especially important that our organisation is working in partnership with five federal ministries and organisations from the realm of development cooperation. That helps us to strengthen the position of the German water industry on the global market and the acceptance of German policies in this sector.

Where are you active?

To date we have been working in 17 countries and regions of Europe, Asia, North Africa, South America and the Middle East. Our premise is that the water crisis cannot be tackled just with technology. Instead we have to raise awareness among the local people and train them in using water sustainably. Capacity development is the watchword here. We train technical staff and establish structures in associations and authorities.

'Appropriate technology' is often mentioned. What exactly is that?

25 percent of global supplies in the water business come from Germany. However, in this country we have eight times more water than we actually use. That is not the case for many regions in the world. Therefore the technology must be appropriate for the target country, because there is little water available, because the precipitation distribution is different, because people use water differently, or simply because there isn't even the most basic infrastructure.

Can you give me an example?

In a lot of countries they lose half the drinking water through the piping system. If we just help with pumps, and with maintenance and repairs to the pipes, it can make a big difference. In water-poor regions like Jordan as much water as possible has to be treated and used over and over again, for example by small decentralised local treatment plants. The biggest problems worldwide are still with sanitation and sewage disposal, because investment costs for

these are high and people don't see the point. Many of them still have no notion of the value of water and wastewater resources.

What can German firms do better than the competition from, say, France or the USA?

German technology is considered reliable and efficient, and German engineers competent and innovative. In particular we are well known for providing individual designs rather than making do with prepackaged, standard solutions. This flexibility proves to be a decisive factor in the water sector as well.

How exactly are you helping?

We are currently working together with regional partners in Hanoi in Vietnam and Karlovac in Croatia to establish two training centres, where technical personnel and authorities will be trained from 2012.

Besides this, German and Vietnamese experts are jointly devising plans for regulated sewage disposal in industrial zones, so that the arrival of businesses helps economic development and environmental protection at the same time. In Jordan they have succeeded in reducing the energy consumption of water supply services by a quarter and doubling production for the capital Amman by means of modern pumps and control systems.

Can you also help if the government of a country has little interest in solving its water problems?

Of course we need to have contacts in the governments of the countries. It is the government's responsibility to facilitate cooperation. A sustainable water supply service only functions if there is an appreciation of the high value of water as a resource. After all, people all over the world value their mobile phones, for instance, and are prepared to pay for them.

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