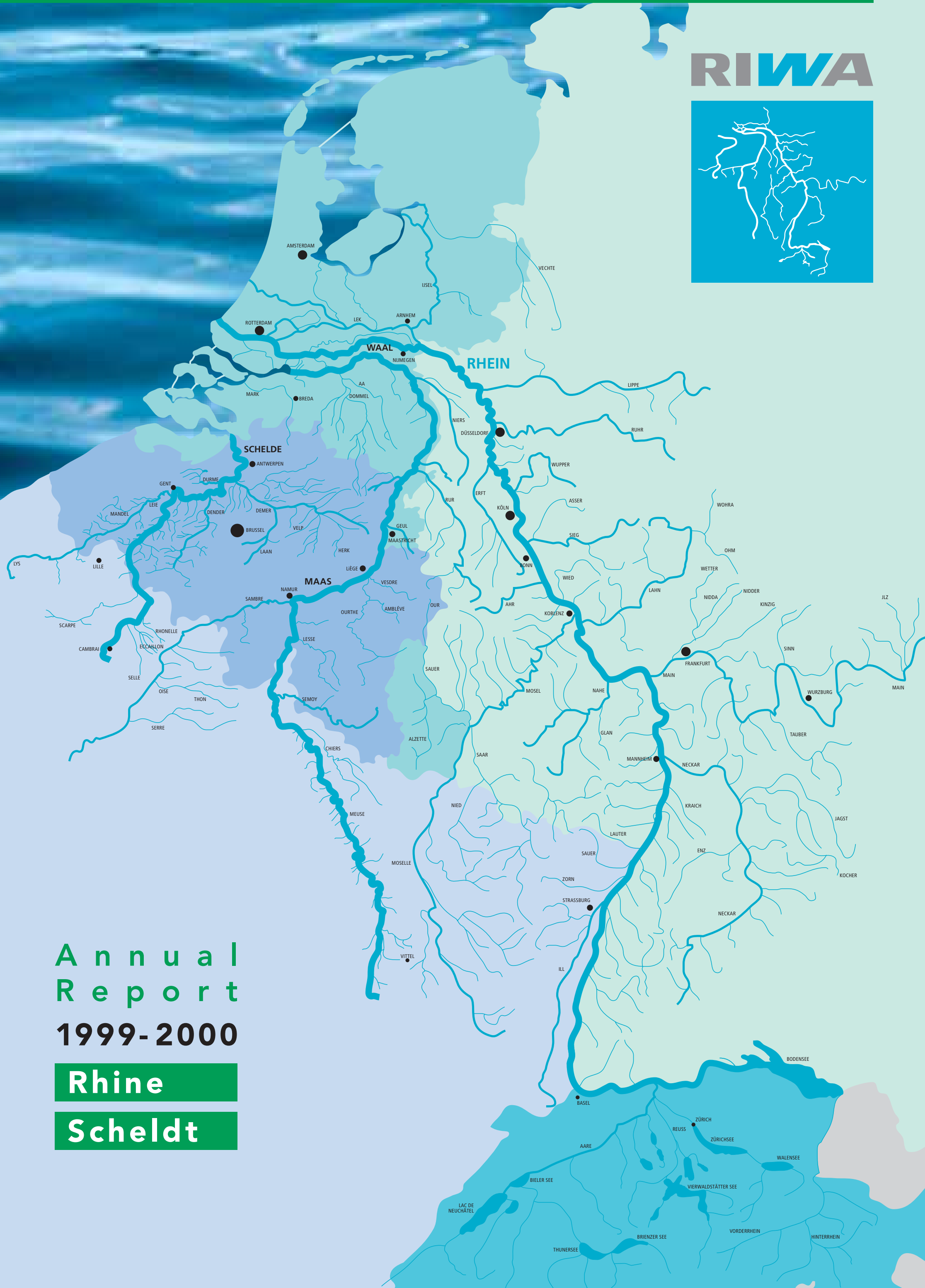
Association of River Waterworks

RIWA



Annual Report

1999-2000

Rhine

Scheldt

RIWA

Association of River Waterworks

Annual Report 1999-2000

Part D The Rhine and the Scheldt

The annual report consists of 4 parts:
part A (the Rhine River), part B (The Meuse River),
part C (The Scheldt River) and
part D (the Rhine and the Scheldt)
each of which are published independently.

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Introduction

Of the two years under discussion in this annual report, 2000 in particular was an extraordinary year for water policy. Various matters have led to taking a fundamentally different course with respect to water. With the title given to a pre-study for the 4th Water Economy Memorandum, a different tone was already perceived in 1995. The outlook note in question was called “Room for Water”. In 2000 it became clear along various fronts that in the meantime a small landslide (maybe an unusual metaphor with respect to water) had taken place with regard to the water quantity focus area.

Need for water

At the Second World Water Forum, which was held in the Hague from March 17 through 22, 2000, the water quantity, the amount of water, took on a particularly central role as a concept related to providing a need. The Rhine River was presented on one of the Forum days as an example of successful flow management.

Water control

When the Netherlands government was given the recommendation “Water policy for the 21st century” on August 31, 2000, the key word water quantity also appeared to be part of the core of the message. In this recommendation, which is focused on the situation in the Netherlands (and in a certain sense in Western Europe), the emphasis is especially on dealing with a great deal of water and creating space for it, and to a lesser degree on water shortage.

Watershed

After many years of negotiations, the European environmental ministers and the European Parliament reached an agreement about the European Water Framework Directive in the summer of 2000. The directive was published in the European Communities Publication as early as December 22 of that year and took effect on the same day. It is true that the Framework Directive is especially focused on protecting and improving the aquatic environment, and, along with this, on the quality of water; but those who drew it up are aware that the quantity of water available for this is of equal importance. The most obvious component of that opinion is that central place taken up by the watershed. After all, that is the only possible approach for effectively tackling the water quantity and that can at the same time ensure that controlling the water quantity can never be lost track of.

Rhine salt procedure

After twenty years of litigation, a remarkable move was made on April 11, 2000 in a legal chess game surrounding the water quality of the Rhine River. The remarkable move, in a game which had mainly consisted for many years of consecutive granting and cancelling of discharge permits, was a verdict to compensate damage.

The scene of the action was the administrative court in Strasbourg. On one side are the French government and a French state company and on the other side a number of Dutch parties, including a province, a municipality and a few polder districts. The dispute concerned the discharge of brine (water containing waste salt) which is discharged into the Rhine river at the Alsace. Further on in this annual report there is a summary on a time-scale about the international results of almost one century of potassium production in the Alsace. The administrative procedure, which was begun on February 18, 1981, and led to such an unusual verdict in April 2000, was at the centre of the time frame.

13th Rhine Minister Conference

A turnaround in thought about the water policy can be detected when comparing the themes of the 1st Rhine Conference of Ministers with those of the 13th Rhine Conference of Ministers which was held on January 29, 2001 in Strasbourg, the city in which the European Parliament was established in 1979 and where the Rhine salt court cases had started. In the first Rhine conference of 1972, salt and chemical and thermal pollution of the Rhine were the central themes. Almost thirty years later, two different communiqués were published as a result of the 13th Rhine Conference of Ministers, which show that on the one hand the watershed approach from the European Framework Directive was focused on, and on the other that the starting signal was given for durable development of the Rhine in the next 20 years with the “Rhine 2020 program”.

Rhine watershed steering group

In addition to ministers from the International Rhine commission treaty nations (Germany, France, Luxembourg, the Netherlands, Switzerland), ministers from other countries or provinces in the Rhine watershed (Liechtenstein, Austria, Wallonia) were also invited this time. The principal decision of the ministers concerned the institution of a steering group for co-ordinating the operations for the framework directive on the Rhine. Switzerland (not a European Union member nation) also participates in this steering group.

“Rhine 2020 program”

During the Rhine conference, the ministers from the IKSR treaty nations gave their approval to the “Rhine 2020 program” for a durable development of the Rhine. It is the progressive sequel of the Rhine Action Program from the eighties. The progressiveness is expressed mainly in the integration of prevention of high-water and improvement of the ecosystem – an 800 km long biotope network along the Rhine is intended – and because ground water protection is also included in the program. It is also unusual that the more than 20-year-old RIWA and IAWR requirement, namely that extracting drinking water must be possible with simple natural purification methods, is also included in the objectives. Both communiqués of the 13th Rhine Conference of Ministers have been printed at the end of this annual report.

Changes at RIWA

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Many studies were concluded in RIWA context in the year 2000, making it possible for the same number of reports to be published. Further on in this annual report a chapter is dedicated to the multitude of reports that were published. In addition, how RIWA must anticipate the watershed approach of the Water Framework Directive was also examined in 1999 and 2000. The decision formation about that changes the set-up of the organisation over the next few years.

Scheldt water

At the end of 1999, the Flemish Water Supply Company (VMW) joined RIWA. VMW is headquartered in Brussels and supplies drinking water to 2.5 million residents spread out over Flanders. In addition to ground water, the company has been extracting water for its provision area from the Bossuit-Kortrijk Canal, which is connected to the Scheldt, since 1995. This river originates in the north of France and then flows through Wallonia and Flanders and flows into the North Sea via the Western Scheldt inside the Netherlands. Thus, an entirely new watershed has been added to the RIWA work area with the entry of the VMW.

Name change

By adding the Scheldt, RIWA could no longer operate under the name “Co-operative Rhine and Meuse Water Companies”, and therefore it was decided to change it. For that matter it wasn’t the first time the name had been changed. Upon its foundation in 1951 the organisation had been called “Rhine Commission”, but in 1952 the name had already been changed into “Rhine Water Company Commission” (abbreviated as RIWA) in order to prevent being confused with the (1950) “International Rhine Commission”. After two Belgian Meuse companies joined and after the changeover by Rotterdam and The Hague to Meuse water in the seventies, the name was changed again to “Co-operative Rhine and Meuse Water Companies” in 1983. That name was also recorded in the statutes under which RIWA was registered as an association in November 1997.

River water

This time it seemed desirable to invent a name which could serve to indicate watershed in a general sense. In the end, “RIWA” appeared to provide the basis for the most elementary part of the new name: river water. In accordance with the change in statues of November 25, 1999, from then on RIWA has been called: “Association of River Waterworks”.

Rhine, Meuse and Scheldt

Due to the entry of VMW beginning in the year 2000, the RIWA focus area was widened and three divergent watersheds (of the Rhine, Meuse and Scheldt) could be compared with one another. The Scheldt is a rain water river just like the Meuse, but there are also differences between the two rivers. The signing of the treaties for protection of the Meuse and the Scheldt in 1994 meant that the remediation of these rivers was being taken seriously. As a result of the activities of the International Meuse and Scheldt commissions since May 1995, the repair of the two watersheds has gradually taken shape. From now on, RIWA will also support activities for the Scheldt.

Reorganisation

In November 2000 it was decided to fundamentally change the organisation of RIWA, with a more independent pursuit of policy between the Rhine, Meuse and Scheldt companies as its core.

Dividing Rhine, Meuse and Scheldt

The RIWA organisation has been characterised since 1990 by a division between Rhine and Meuse activities. This division in watersheds was mainly introduced at the time in order to be able to intensify the activities along the Meuse. In the course of 2000 it appeared that a number of companies among the Rhine and Meuse companies needed more independence. On the one hand this would possibly limit the costs of the organisation. On the other, the companies could operate more independently within their own watersheds and better anticipate the watershed approach of the European Water Framework Directive, which took effect at the end of 2000.

Independent departments

At the end of 2000, the decision was made to start working with two independent Rhine and Meuse departments under one RIWA umbrella organisation beginning in 2001. In principle, the Scheldt also forms a separate department, but since it is formed by one company, for the time being the independence of this department is limited. The RIWA Rhine and RIWA Meuse departments are managed by a separate director, the RIWA Scheldt by the director of the Scheldt company. Many activities such as measurement network, special studies, consultation with third parties (e.g. the International Rhine, Scheldt and Meuse commissions) and lobbying will be carried out by the departments themselves from now on.

Separate and together

At the administrative level, the departments gather to exchange experiences, synchronise their activities and discuss possible forms of co-operation. The combined consultation with the Netherlands federal government is maintained. The watershed-oriented RIWA Meuse, RIWA Rhine or RIWA Scheldt departments will operate principally within the catchments. In areas in which specific watershed interests do not play a significant role, the Association of River Waterworks – RIWA – will continue to determine the public image to be presented.

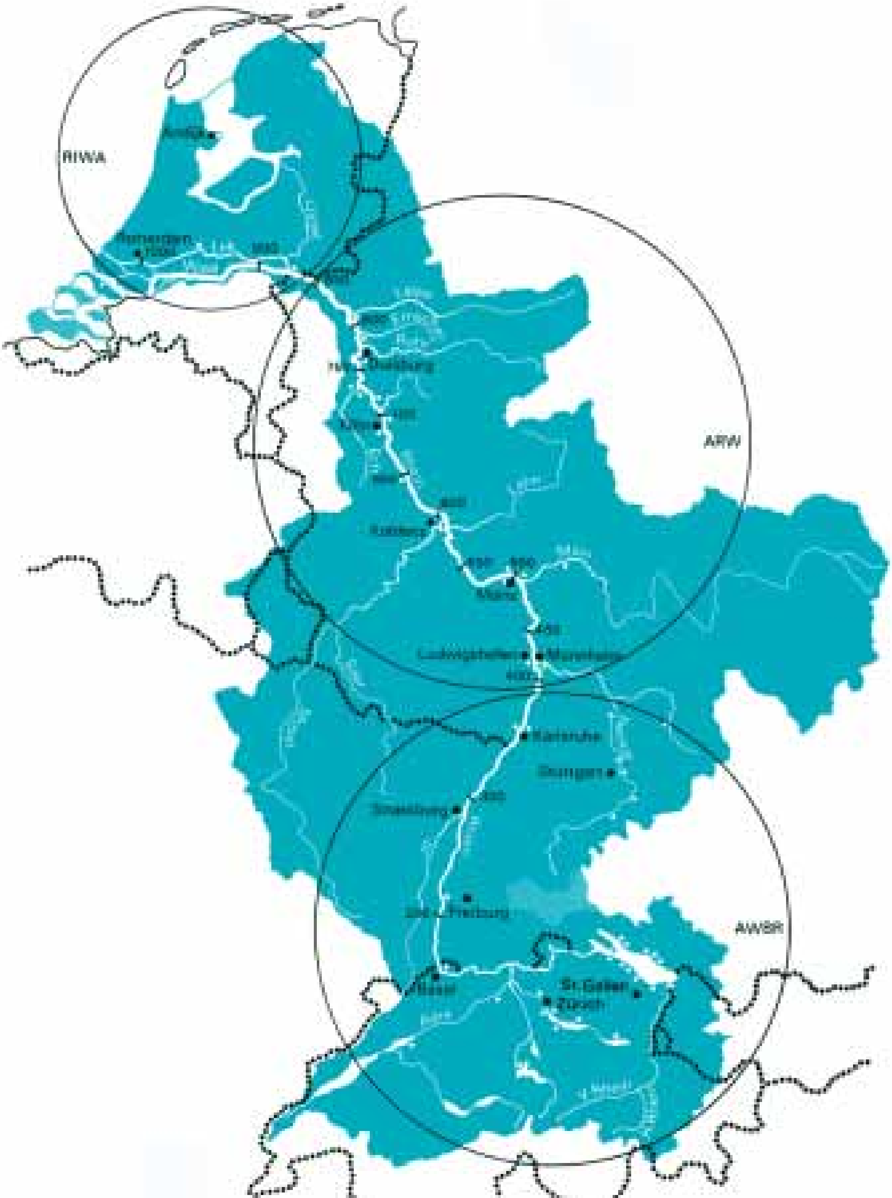
Chairmanship

The general chairmanship of RIWA is rotated every three years among the Rhine and Meuse companies. After the departure of Mr. Merckx (Antwerp Water Works) in September 1999, Mr. Leemans (Brussels Intercommunal Water Company) was elected general RIWA chairman in 1999. Starting in 2001, the general chairmanship was transferred to the Rhine companies once again. Mr. Gast has assumed the post of general RIWA chairman since January 1, 2001.

Department chairmen

Meanwhile, it was also decided to subdivide RIWA into watershed-oriented departments each with its own department chairman. As a result of this, Mr. Gast also assumed the chairmanship of the RIWA Rhine department starting in 2001. Mr. Leemans was appointed chairman of the RIWA Meuse department.

The Rhine, Meuse and Scheldt RIWA-sections (Figure: Municipal water systems, Ad van der Meer)


RIWA
ARW
Duisburg
Köln
Koblenz
Mainz
Ludwigshafen
Mannheim
Karlsruhe
Stuttgart
Strasbourg
Freiburg
AWBR
Basel
St. Gallen
Zürich

The quality of the Rhine water

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The “Vorderrhein” and the “Hinterrhein” originate in Switzerland and flow together some tens of kilometres further and form a fast-flowing mountain river: the Rhine River. With a length of 1320 km, the Rhine is one of the medium-length rivers. Fed by rain and melting water from nine countries, it finds its way to the North Sea. The principal tributaries carry water from Austria, Switzerland, France and Germany.

Average discharge

In Basel, the average discharge is already 1,000 m^3/s; in Lobith this has increased to 2,300 m^3/s. The average current speed of the river varies in the Netherlands from 0.5 to 1.5 m/s with peaks above 2 m/s.

Watershed

The Rhine’s watershed surface area is 185,000 km^2, 25,000 km^2 of which lies in the Netherlands. With this, the Rhine watershed in the Netherlands takes up a large amount of the Netherlands’ territory, which has a surface area of 34,000 km^2. Approx. 50 million people live and work in the Rhine watershed, 30 million of whom receive drinking water that has been produced directly or indirectly from Rhine water.

Monitoring the water quality

Just like other important European rivers, the Rhine is the pre-eminent means of transport for waste water and other waste substances which caused the Rhine water quality to deteriorate so much during the industrial revolution. For inland navigation, the Rhine forms an important transport route between the seaports along the North Sea and the interior ports in the countries of the watershed, meaning between the Netherlands and Switzerland.

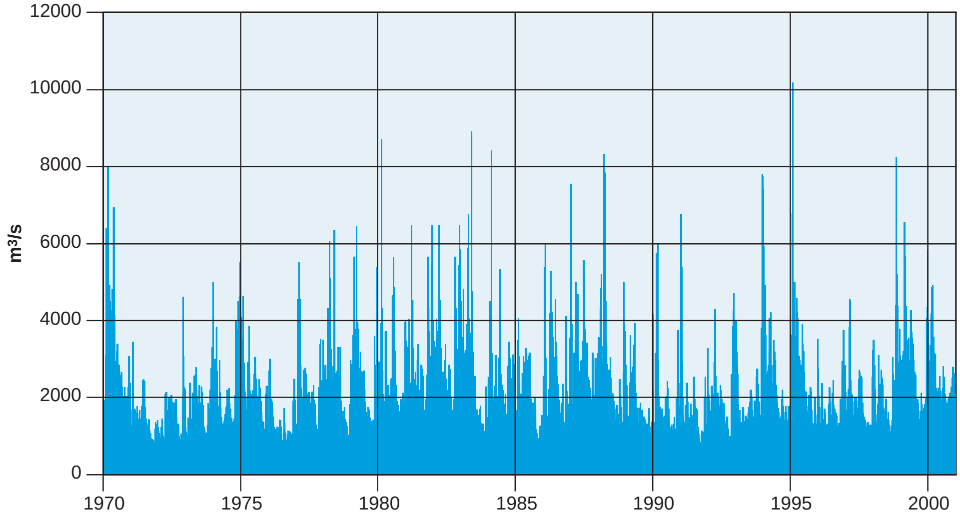
Because the Rhine water is used intensively for production of drinking water and industrial use water, the water companies closely monitor the Rhine water quality. The water quality is monitored continuously at various (automatic) measuring stations of the governments and laboratories of the large water companies along the Rhine. In this manner, measures can be taken quickly in case of contamination, but it can also be verified whether environmental policy measures have led to any results. In case of accidents, the Rhine warning and alarm system warns the drinking water companies that take in river water downstream. At any rate, increasingly more often the large industries themselves report any accidents.

In addition to chemical measurements, there are also biological monitoring systems in use: flow-through tanks with bacteria, algae, mussels, daphnia and/or fish which are continuously exposed to the river water. Their behaviour is monitored electronically and when there is a deviation the alarm is sounded. The number of alarm reports in the Rhine showed considerable decrease over the past ten years.

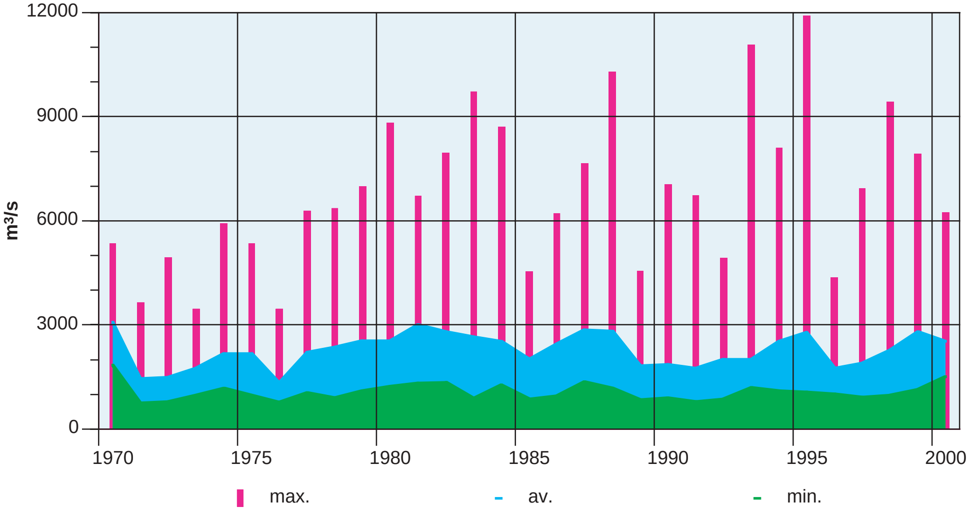
Water discharge

Upstream from Basel the discharge is determined by melting snow water and a few glaciers, with peaks in the early summer months as a result. Downstream from Basel, the effect of rain water is considerable during fall and winter. On average the discharge of the Rhine at Lobith is highest in the winter. At that time evaporation is lower and the Rhine discharges mainly rain water. The contribution from the Alps in the winter is only 30 percent

Rhine water discharge at Lobith 1970-2001 (week sample)

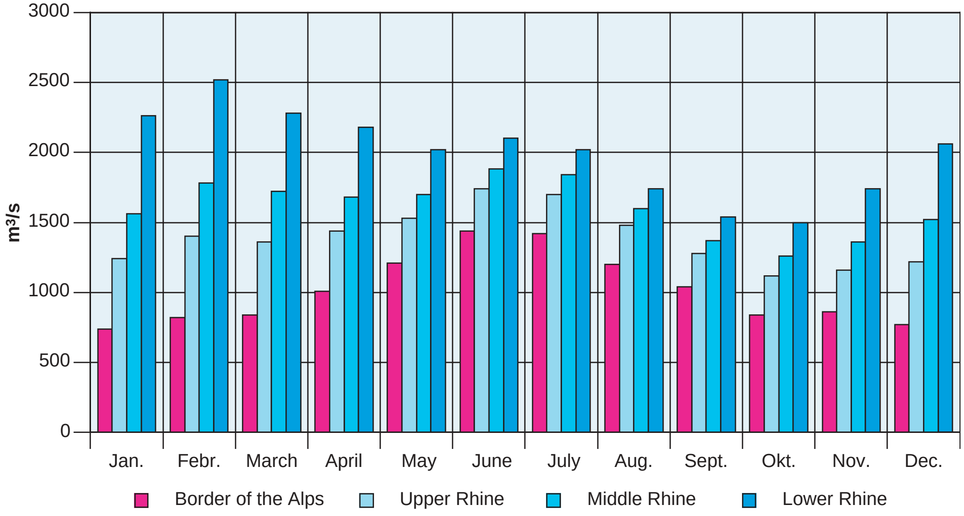


Rhine water discharge at Lobith 1970-2001 (index numbers)



because a large portion of the precipitation remains on the ground in the form of snow. In the summer, more than 70 percent of the Rhine water at Lobith originates in the Alps area. The mixed discharge regime of the Rhine ensures a relatively regular discharge pattern, making the river navigable and making water extraction by drinking water companies, agriculture and industry possible the whole year round.

Rhine water discharge at Lobith 1931-1990



High water

Throughout the centuries, the Rhine watershed residents have had to live with surplus water. Dikes regularly broke, not only as a result of high water but also of blockage by drifting ice. High water levels are part of a river and cannot be predicted much in advance. To protect people and their property, the river dikes have been raised and reinforced for centuries. Because further dike raising is not indicated, alternatives are being sought. “Room for the River” and increasing the “stretch” in the river system for compensating high water peaks have become the mottoes of the Dutch river policy.

The discharge itself depends on factors such as climatologically conditions, properties of the watershed and on human intervention.

The speed of the discharge of a river is determined by river characteristics such as geometry (width, depth, bends) and the texture of the river bed.

1993 and 1995 high water

Extreme high water levels occurred in the Netherlands and upstream in 1993 and 1995. At the end of 1993, the highest discharge was measured in the Meuse since humans began recording: 3120 m^3/s. In January 1995 the Rhine was also at extremely high level with a peak discharge of about 12,000 m^3/s at Lobith, the next to the highest level ever measured.

1996-1998 low water

Over the following two years (1996-1997), the Rhine had relatively low water levels, followed by a normal water level in 1998. High water did not occur again until 1999, which led to flooding from the Bodensee to the Lower Rhine. The high-water level at the Bodensee was the highest of this century. The discharge in the entire Rhine watershed was above the long-term average for the 1931-1991 period.

1999 high water

The high water periods of 1999 were in the months of February-March, May-June and December. The high water from the end of February to the beginning of March of 1999 was caused by extensive rainfall in the Upper and Middle Rhine areas. The high water in the early summer of 1999 was caused by extreme rainfall in Switzerland (May 4-22), especially in the eastern part and the Aargau and Zürich cantons. The relatively high air temperatures caused it to rain up to 2700 m, making the snow melt even faster at that level. These extreme climatological conditions (high air temperature and a great deal of rain) caused flooding especially in the area of the Bodensee and along the High and Upper Rhine. The Zürichsee reached a unprecedented water level of 407.01 metres and the discharge from the lake was unusually high in that month (May), causing a record discharge from the Limmat of 550 m^3/s (as opposed to 100 m^3/s in regular years).

A third high-water surge occurred in December 1999, thus in a period which is characterised by high water more often (the so-called advent or Christmas high water). The discharge at the Lower Rhine rose above 6000 m^3/s, caused by severe rainfall in the Upper and Middle Rhine watersheds. Tributaries such as the Main and Mosel also discharged noticeably more water in 1999.

Not only did the floods cause water problems in the areas in question, but also large quantities of contaminated sediment. Some of that sediment originated in the flooded areas themselves, another portion was remobilised sediment from dammed-up reservoirs. In addition to high concentrations of heavy metals (arsenic, cadmium, chromium, copper and lead) such sediment may also contain toxic organic substances, such as PAH (polycyclic aromatic hydrocarbons), HCB (hexachlorobenzene) and PCB (polychlorobiphenyls).

Water discharge 2000

The water discharge in the year 2000 was relatively normal again and only 10% above the long-term average at many measuring points.

Causes of high water

The causes of high water can be found in the climatological phenomena (large quantities of rainfall in large areas of the Rhine watershed) and in changes of the river area made by man. Due to changes in the use of the land, the storage capacity (for rainfall) of the vegetation and the soil also change. The water storage capacity of the soil can especially be affected by this. Urbanisation and paving of the ground surface has this effect to an even higher degree. Other large interventions by man involve the rivers themselves: river canalisation and the installation of dams and storage reservoirs.

Solutions

By increasing the storage capacity of the watershed and the river system, peak discharges can be reduced. By installing retention reservoirs or flooding areas, a great deal of water can be stored during high-water surges. Such measures are especially effective upstream, but such areas are also needed in the Netherlands. Retention areas have been installed along the Upper Rhine which all together will hold 270 million m^3. Retention areas have also been installed in Nordrhein-Westfalen. This involves 4000 hectares of surface area, where a maximum of about 170 million m^3 of water can be stored.

One does have to keep in mind that retention reservoirs should be avoided as much as possible in drinking water protection areas due to the risk that harmful substances from water and sludge may reach the ground water layers.

General parameters

Clean river water is important for all of those who use it. The Rhine, heavily polluted for many years, has become considerably cleaner as a result of international treaties and remediation measures, but certainly not clean enough.

Water temperature

The water temperature was at the level of the previous years at all measuring locations during the reporting years. Analysis of the measurement numbers of the past 50 years show a slight rise of the water temperature of the Rhine. Thus it may be assumed that the Rhine has become warmer (and more salty) over the past century. As a matter of fact there are a few salt and heat-loving organisms living in the Rhine which originally did not belong there. Since the fifties, the water temperature of the Rhine has risen nearly half a degree Celsius per 10 years, mainly as a result of cooling water discharges from power plants and industry.

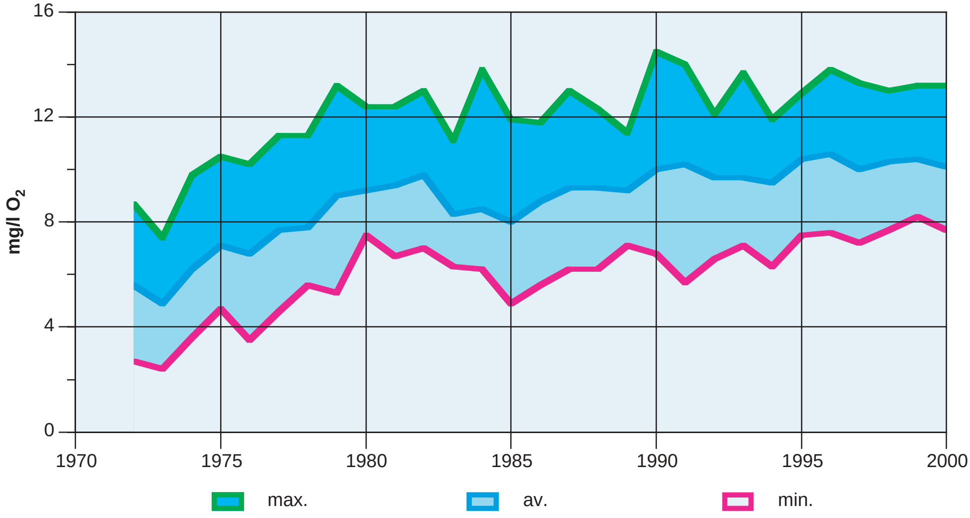
Oxygen

For many years, the Rhine was THE symbol for water pollution on the European scale. The water quality in the watershed deteriorated frightfully, particularly in the rebuilding and industrial development period after the war.

The oxygen concentration in the foaming, stinking water was often reduced to less than 3 mg/l during the summers in the 1960-1975 period. This is much too low for many fish species, resulting in the death of many fish with a nearly dead river as the consequence.

Nowadays the oxygen concentration at all measuring locations appears to be high enough that even sensitive fish species can survive. The oxygen saturation of the river water, which depends on the oxygen concentration as well as the water temperature, exceeded the IAWR quality requirement of 80% at all locations. The 90 percentile was above 90% everywhere.

Rhine water oxygen concentration at Lobith (1970-2000)



ECC

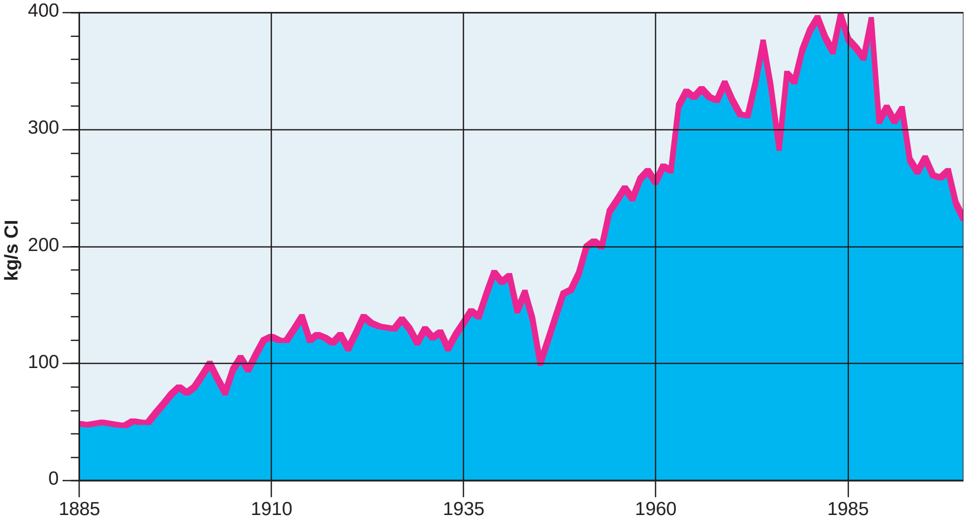
The electrical conductivity capacity appeared to fluctuate around 70 mS/m in the Middle and Lower Rhine in 1999 (as 90-percentile) and this made it lower than in the previous years. This effect occurs due to dilution as a result of higher discharge, but comparison of the analysis results of the past ten years shows that the significant drop is also the result of decreasing chloride concentrations.

Inorganic parameters

Chloride

According to measurements of the Amsterdam Municipal Water Company, the natural chloride load of the Rhine water at Lobith has been 50 kg/s since 1885.

Rhine water chloride load at Lobith (1885-2000)



However, in the eighties, loads as high as 400 kg/s were measured.

Meanwhile, the situation has clearly improved and the salt concentration of the river averages about 100 mg/l Cl nowadays.

The chloride load of the Rhine is mainly caused by industrial discharges by the potassium mines in the Alsace, the salt industry in the French part of the Mosel and the German coal mines. The natural salt load of the Rhine, which originally was 50 kg/s at Lobith, is washed by the rain from salt-containing stones and bottoms.

The chloride load, which is minor at Basel, shows a sudden increase at the Karlsruhe measuring point where discharges from the Alsace are registered. The load from the potassium mines is around 2 million per year.

The downstream tributaries Neckar and Main transport little salt in comparison. The load for the two rivers combined is around 0.5 million tonnes of chloride per year. The situation along the Mosel, which transported about 1.5 million tonnes of chloride to the Rhine in 1999, is different. That salt is created by the industry in the French Lorraine. This makes the salt discharge via the Mosel almost as great as the one from the potassium mines – and in both cases created in France.

Yet Germany also contributes considerably to the salt load at Lobith: about 2.5 million tonnes of chloride per year is created by the coal mines, a load which reaches the Rhine mainly via the Emscher and the Lippe.

The salt load was significantly reduced over the past 10 years: at the Karlsruhe measuring station from 4 to 2 million t/a, at Lobith, however, only from 10 to 8 million t/a. These numbers also make it clear that the salt loads which are introduced into the Rhine via the Mosel, the Emscher and the Lippe are still considerable.

Along most of the measuring locations on the Rhine the IAWR quality requirements for chloride are not exceeded. A (minor) limit exceeding of the limit value of 100 mg/l (as 90-percentile) could be established only at Wesel and Lobith.

Table 1 Chloride concentrations in the Rhine watershed in 1992-2000
(Concentration in mg/l Cl)

Year	Lobith		Nieuwegein		Andijk		Stellendam	
	av.	max.	av.	max.	av.	max.	av.	max.
2000	92	129	95	124	104	133	75	106
1999	95	173	90	138	95	134	85	156
1998	128	205	113	156	136	194	104	220
1997	147	246	128	182	157	205	131	235
1996	157	259	138	190	203	330	146	235
1995	120	226	108	198	121	185	100	205
1994	120	210	111	154	116	150	122	234
1993	151	236	141	188	161	220	141	235
1992	175	305	151	241	202	255	138	222

Sulphate

The concentrations of other inorganic substances were also reduced in 1999 and 2000, presumably due to the dilution effect as a result of higher discharge. For some substances a minor increase in their concentrations could also be detected. For example, the sulphate concentration between Mainz and Lobith increased from about 50 to about 70 mg/l, but was still below the IAWR limit value of 100 mg/l.

Sodium

The sodium concentration has been decreasing at all measuring points for 10 years already, a reduction which is linked to the drop in the chloride concentration.

Table 2 Sodium concentrations in the Rhine watershed in 1992-2000
(Concentration in mg/l Na)

Year	Lobith		Nieuwegein		Andijk		Stellendam	
	av.	max.	av.	max.	av.	max.	av.	max.
2000	57	71	52	70	58	74	42	89
1999	57	95	52	77	52	76	46	89
1998	66	87	59	78	72	96	57	133
1997	81	112	70	101	85	112	72	127
1996	85	127	76	95	111	175	80	128
1995	67	100	54	77	67	102	56	117
1994	70	90	62	83	63	84	70	263
1993	82	107	78	105	89	120	71	117
1992	88	148	80	124	109	139	72	111

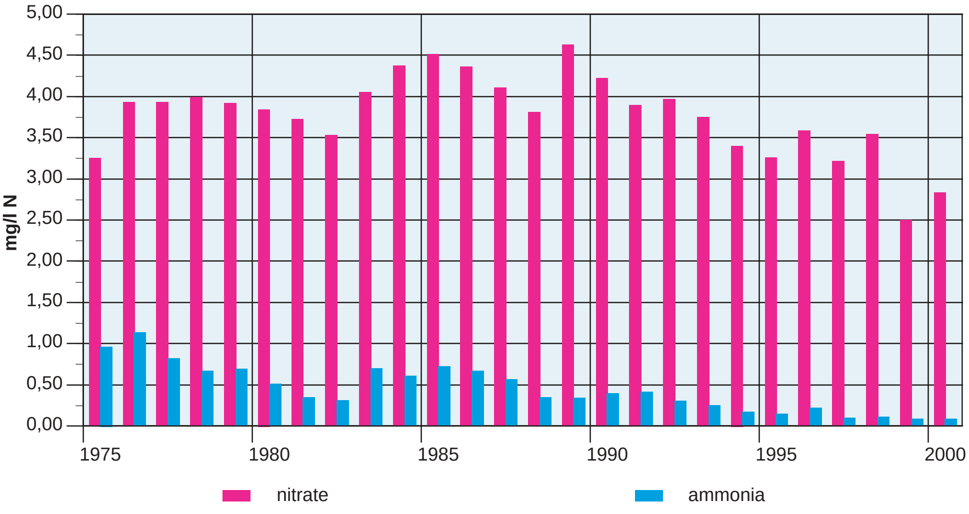
Nutrients

Phosphates and nitrogen compounds are nutrients which may cause excessive growth of algae in the surface water. This results in a reduction of the oxygen concentration in the water, to production of odorous substances and sometimes also of algae toxins. After installation of numerous sewage plants in the 1970-1980 period, fewer organic waste products, and therefore also fewer phosphate and nitrogen compounds end up in the river with the discharge water. This lowered the ammonia concentration, while the nitrate concentration barely changed. This is because ammonia is released during decomposition in sewage plants which is consequently transformed into nitrate (nitrification). The sewage plants are working on denitrification of the waste water for further reduction of the nitrogen concentration.

Ammonia

The ammonia concentrations at most measuring locations were below the IAWR limit value of 0.3 mg/l in 1999. However, 0.49 mg/l was measured at Wesel. The ammonia concentrations vary widely, depending on the season and temperature. Because ammonia barely decomposes in the winter

Rhine water nitrogen concentration (nitrate and ammonia) at Lobith (1975-2001)



months, the concentrations during that period are also much higher than in the summer months.

Nitrate

The nitrate concentrations between Mainz and Lobith used to vary from 12 to 18 mg/l which is below the IAWR quality requirements of 25 mg/l. However, for the water companies along the Rhine, these numbers are already cause for concern: they often extract ground water with higher nitrate concentrations and mix this ground water with Rhine water in order to so obtain lower nitrate concentration in their drinking water. If the nitrate concentrations of Rhine water increase further this means higher purification costs for some drinking water companies.

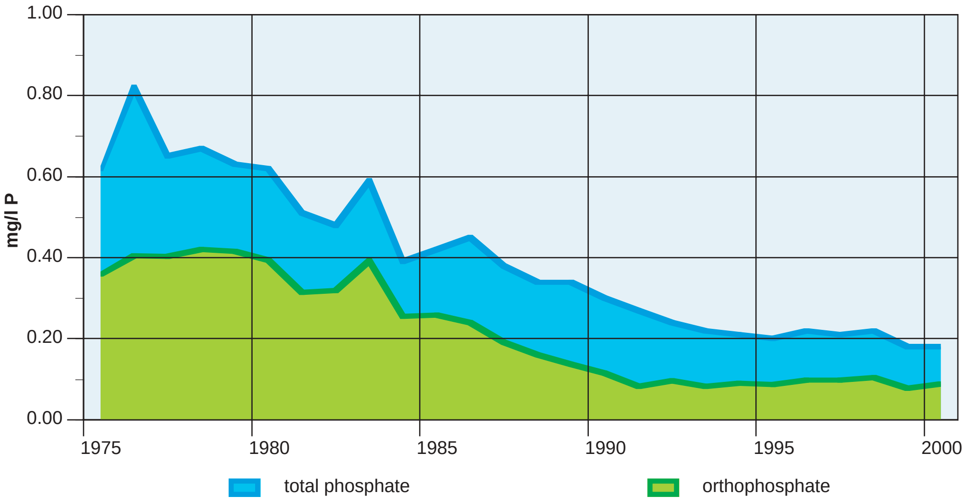
In some tributaries, the nitrate concentration may be significantly higher. The concentration in the Main at Frankfurt was around 26 mg/l (as 90 percentile) which already exceeded the IAWR limit value.

Phosphate

The phosphate concentrations of the Rhine remain at a relatively low level or are further reduced in the Middle and Lower Rhine. The orthophosphate and total phosphate concentrations are of little importance to the drinking water companies along the Rhine.

However, water companies which extract their water from lakes do have to deal with these substances, since higher phosphate concentrations may stimulate the production of algae.

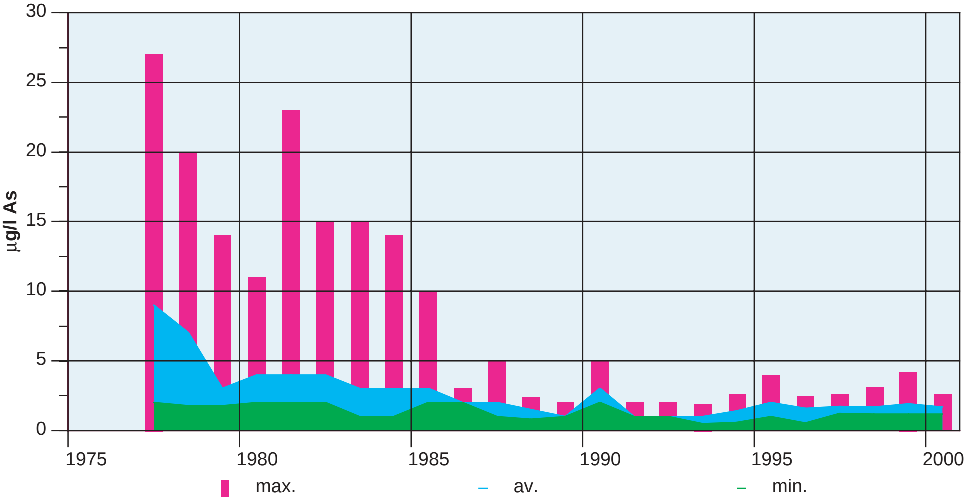
Rhine water phosphor concentration (orthophosphate and total phosphate) at Lobith (1975-2001)



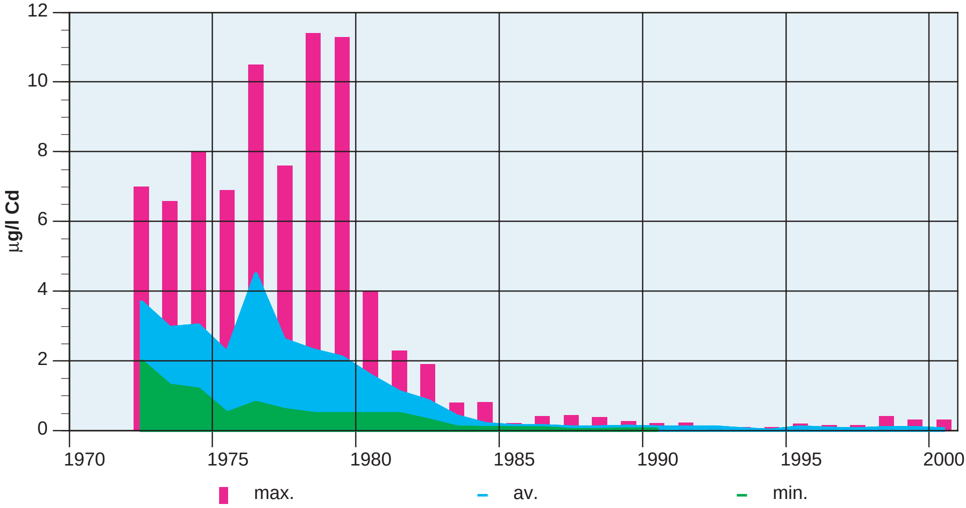
Metals

From around 1950 until during the 1960-1970 period, the heavy metal concentration in the Rhine increased considerably. In the seventies, the Rhine water exceeded the Dutch standards by a factor of 5 to 25 on average. After that the concentrations decreased to a large extent until about 1985 and since then they have just about stabilised. The heavy metal concentrations in the Rhine are now around the limit value.

Rhine water arsenic concentration at Lobith (1975-2001)



Rhine water cadmium concentration at Lobith (1970-2001)



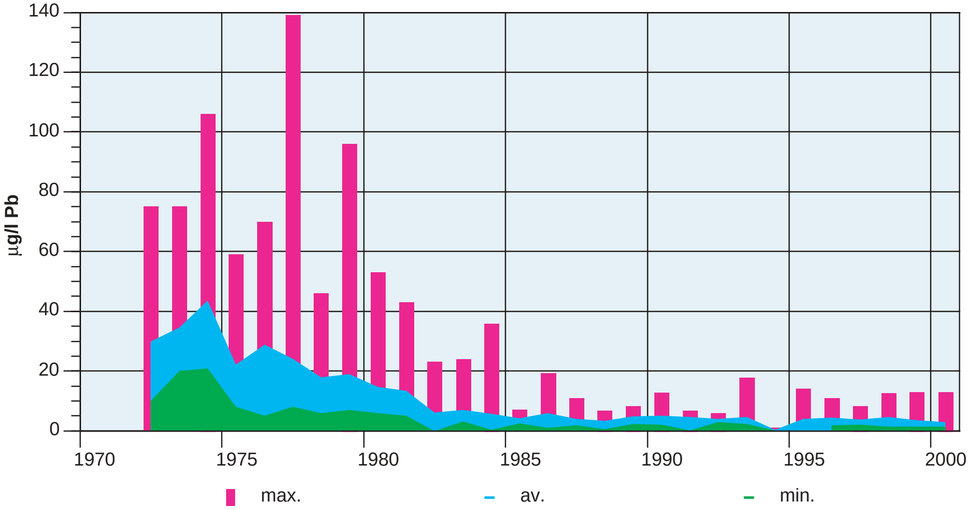
Metals are mainly absorbed by floating matter and drinking water companies must separate and remove these during flocculation and sedimentation. The arsenic concentration is especially important in this because arsenic-containing sludge may not be spread on agricultural soil as a mutagenic compound. Arsenic is partially of natural origin. It can be demonstrated in relatively high concentrations in creeks and tributaries originating in the Eiffel.

Even if the heavy-metal contamination in the water itself is minor nowadays, it is still causing problems in the water bottom. The cadmium and mercury concentrations in dredge sludge are often so high that the sludge may not be dumped without extra precautions.

Boron

Water companies have been measuring the boron concentrations in the Rhine for a few years now. Boron is an indicator of waste water discharges and can pass through bank soil layers and slow sand filters. It is true that the IAWR quality requirement of 0.2 µg/l (as 90 percentile) has not been exceeded so far at any measuring location, but it is still necessary to follow this parameter. The measuring values in the Middle and Lower Rhine were between 0.08 and 0.12 µg/l in 1999.

Rhine water lead concentration at Lobith (1970-2001)



Organic sum parameters

DOC

The DOC loads (dissolved organic carbon) in the Rhine did not show any big changes over the past 20 years, but they do vary from year to year. This is caused by changes in discharge, which increased from 1997 to 2000 resulting in an increasing DOC load for the area between the Upper and Lower Rhine.

AOX

The AOX concentrations (absorbable organic halogen compounds) in the Rhine and its tributaries show only slight changes in the 1996-2000 period. In the Upper Rhine area (between Basel and Karlsruhe), an average of 5-7 µg/l was measured in 1999. The tributaries, such as the Neckar, contain double that concentration with more than 10 µg/l.

The AOX loads were reduced until the beginning of the nineties and since 1992 have been more or less at the same level: 300 t/a at Basel and 800 t/a at Düsseldorf.

AOS

The concentrations of AOS (absorbable organic sulphur compounds) are much higher. At Basel and Karlsruhe, concentrations of about 40 µg/l were measured in 1999, and concentrations of about 80 µg/l were measured in the Neckar at Heilbronn. AOS is mainly created by the paper and cellulose industries. It is striking that almost no change was detected at any measuring locations between 1999 and 2000.

The AOS loads in the Rhine are about 4 times as high as those of AOX. In 1998, the loads at Basel fluctuated around 1000 t/a, at Mainz around 3000 t/a and at Düsseldorf around 4000 t/a. Since the loads were higher in 1999 (higher discharge) than in 1998 (low discharge), it is suspected that part of the AOS load is of natural origin.

PAH, PCB and dioxins

PAH (polycyclical aromatic hydrocarbons) and PCB (polychlorobiphenyls) belong to the organic micro contaminations. Many organic micro contaminations show the same pattern: high concentrations in the 1950-1970 period and a gradual decrease until the beginning of the nineties. Because these substances are absorbed by sludge particles, the development of the contamination of the Rhine can be read out from the water bottom of the Ketelmeer, Hollands Deep and Haringvliet, among other places. Dioxins are also a problem, especially in the sedimentation areas of the big rivers (Biesbosch, Hollands Deep, Nieuwe Merwede and in deeper sludge layers of the Ketelmeer). They play only a minor role in the water phase nowadays.

Organic parameters

EDTA

Substances such as NTA, EDTA and DTPA which form complexes have been measured in the Rhine since the middle of the eighties. Some substances, such as NTA, are biodegradable, but the majority are not or are broken down very slowly biologically, can pass bank soil layers and slow sand filters and thus can also enter drinking water. IAWR has drawn up limit values for these substances: 5 µg/l for degradable compounds and 10 µg/l for persistent compounds such as EDTA and DTPA. The limit values for some compounds are still exceeded in the Middle and Lower Rhine.

EDTA concentrations double in the Rhine trajectory between Basel and Karlsruhe (from 1.5 to 3.2 µg/l in 1999). In this area, the Neckar, a tributary of the Rhine, clearly shows higher concentrations: 10 µg/l in 1999. The concentrations (as 90 percentile) at the measuring locations along the Middle and Lower Rhine were clearly higher: around 4.6 µg/l at Ludwigshafen and between 7.1 and 8.0 µg/l between Minz and Lobith. High concentrations were demonstrated in the Main: around 19 µg/l at Frankfurt and Bischofsheim.

It was recently demonstrated in the Bodensee how persistent these compounds are. No EDTA has been discharged in the Bodensee for years and it was still demonstrated in concentrations of 1.4 µg/l at a depth of 80 m.

The EDTA loads in 1999 were 180 t/a at Karlsruhe, around 300 t/a at Mainz and around 430 t/a at Düsseldorf. The loads for the year 2000 are at the 1999 level. DTPA, the substitute for EDTA, is used by the paper and cellulose industry. The DTPA loads were still low a few years ago, but meanwhile the Karlsruhe paper mill discharges 40 t/a already, with a tendency to increase this amount. In the 80 m-deep water of the Bodensee a DPTA concentration of 1µg/l could already be demonstrated.

Medications

Water samples from the Upper to the Lower Rhine have been studied for medications since 1996. Three substances are encountered regularly: the anti-convulsive carbamazepine, the anti-rheumatic remedy diclofenac and the substance benzafibrate. The highest concentrations are measured for carbamazepine which is regularly demonstrated to be present in concentrations above 0.1 µg/l between Basel and Lobith.

Table 3 Medications in the Rhine in 2000 (90-percentile, in ng/l)

Substance	Basel	Karlsruhe	Mainz	Düsseldorf
bezafibrate	<10	33	48	63
carbamazepine	23	160	141	220
diclofenac	26	57	67	80
ibuprofen	19	16	<5	12
gemfibrozil	<5	<5	<5	10

Substances with endocrinal effects

Studies of a few chemical substances which may have endocrinal effects have demonstrated that bisphenol-A, octylphenol and the iso-nonylphenols occur in concentrations below or near the determination limit (with a few peaks). The maximum concentrations for iso-nonylphenol were 130 ng/l at Basel and 380 ng/l at Karlsruhe in 1999. In 2000, a maximum concentration of iso-nonylphenol of 350 ng/l was measured at Basil one time.

Table 4 Substances with endocrinal effect in the Rhine in 2000 (90-percentile, in ng/l)

Substance	Basel	Karlsruhe	Mainz	Düsseldorf
bisphenol-A	24	52	44	50
iso-nonylphenol	156	85	143	164

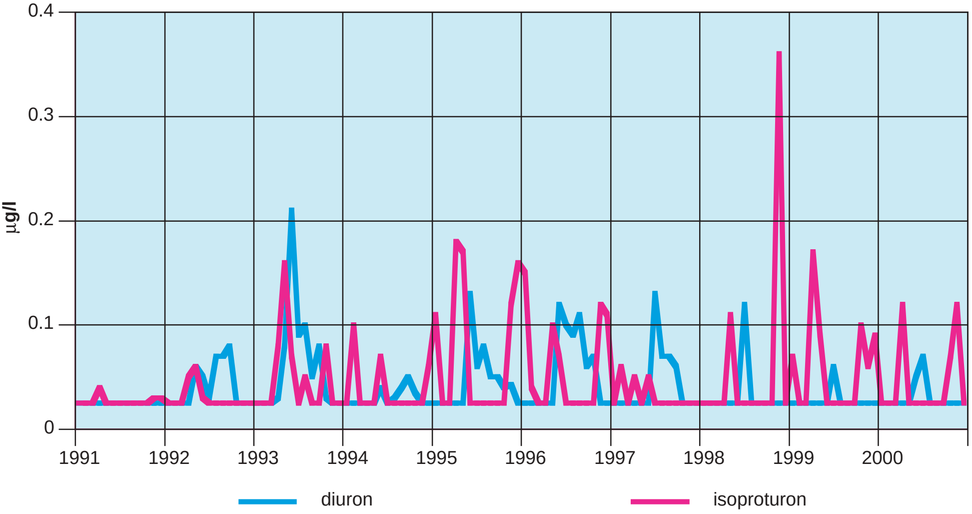
Pesticides

The amount of pesticides in the Rhine clearly decreased in the last 10 years. In spite of that, the limit values are regularly exceeded during the periods when these substances are used in bulk in agriculture. This is especially important to companies such as WRK, which extract Rhine water and use the pre-purified water for dune infiltration. Since a limit value of 0.1 µg/l is used for this application, WRK is obligated to stop taking in water as soon as that limit value is exceeded. The following table shows that this occurs regularly.

Table 5 WRK Water intake stops

Year	Contaminant	Number of days
1969	endosulfan	14
1980	styrene	6
1982	chloronitrobenzene	10
1983	dichloroisobutylether	7
1984	phenetidine/o-isoanisidine	5
1986	"Sandoz": fatty acids,turpentine, 2,4-D herbicide	9
1988	isoforon	5
	dichloropropene	12
	mecoprop	4
1989	nitrobenzene	4
1990	metamitron	6
1994	isoproturon	36
1998	isoproturon	7
1999	isoproturon	7
2001	isoproturon	35
2002	isoproturon	10

Rhine water diuron and isoproturon concentration at Lobith (1991-2000)



Exceeding the limit values for isoproturon (in Cologne with concentrations up to 0.13 µg/l, in Düsseldorf up to 0.40 µg/l) for bentazon and AIPA (Mainz up to 0.14 µg/l) and for glyphosphate and AMPA were detected in 1999. Glyphosphate especially occurs in tributaries in concentrations exceeding 0.1 µg/l, while this substance clearly remains below 0.1 µg/l in the Rhine due to dilution. The situation is different for AMPA, the glyphosphate metabolite, which also occurs in the Rhine at Düsseldorf in concentrations up to 0.5 µg/l and in the Nidda (the largest tributary of the Lower Rhine) up to as much as 6.2 µg/l (1999).

Glyphosphate is applied in many areas, by the German Railways among other companies. Another substance is diuron, which will be used more often by these railways in the future.

Table 6 Use of herbicides by the Railways in Mannheim/Heidelberg 1980-1999

Herbicide	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99
amitrol					x															
bromacil	x	x	x	x	x	x	x	x	x	x										
dalapon			x	x																
diuron	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x				
glyphosphate									x	x	x	x	x	x	x	x	x	x	x	x
hexazinon	x	x	x	x	x	x	x		x	x	x	x								
MCPA	x	x	x	x	x	x	x	x	x	x										
mecoprop P	x	x																		
picloram	x	x	x	x	x	x		x		x										
simazine						x														

Unidentified toxic compounds

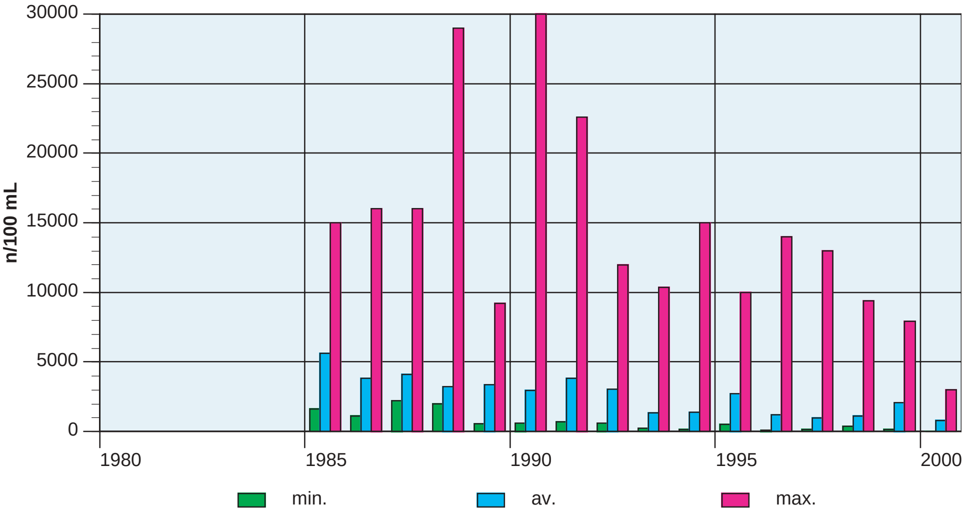
Measurement of chemical parameters often involves clearly identifiable individual substances or small groups of substances. In the overall toxicity of water or sludge, the share of unknown contaminations, the unidentified substances, can amount to as much as 80%. In order to get an idea of the total toxicity, effects from water and sediment are measured in “bio-essays”, laboratory tests in which organisms such as bacteria, algae, daphnias and mosquito larvae are exposed to contaminated water or sediment after which their population growth and development are measured. It is clear that not nearly all relevant substances have been identified.

Bacteriological quality

A large majority of the organisms occurring in surface water are harmless to man, usually very useful and sometimes even indispensable as a link in the food chain. Some aquatic organisms, however, are pathogenic. They can be harmful to human and animal health by causing (contagious) diseases. Disease-generating organisms generally do not naturally occur in water. They are introduced to it by human and animal faeces. The main source of pathogenic organisms is discharge of non-purified or partially purified domestic waste water. Other sources, for example, are waste water from the bio-industry, such as manure producers and slaughterhouses.

Since pathogenic organisms may occur in a large variety in surface water and isolation and culture techniques require a lot of time, it is not possible to determine the presence or absence of the different species by means of routine tests. To this is added the problem that some species may occur in water in small amounts, creating a great chance that a species is not detected in a water sample while it is indeed present in the surface water. One way to solve both problems is to use the condition that pathogenic organisms in water are of predominantly faecal origin and human faeces contain enormous amounts – 108-109 per gram – of mostly harmless intestinal bacteria. Some of these intestinal bacteria, such as Escherichia coli and faecal streptococci for example, are exclusively of faecal origin. These so-

Rhine water Escherichia coli at Lobith (1985-2000)



called "accompanying bacteria" can be used as indicator organisms for demonstrating faecal infection.

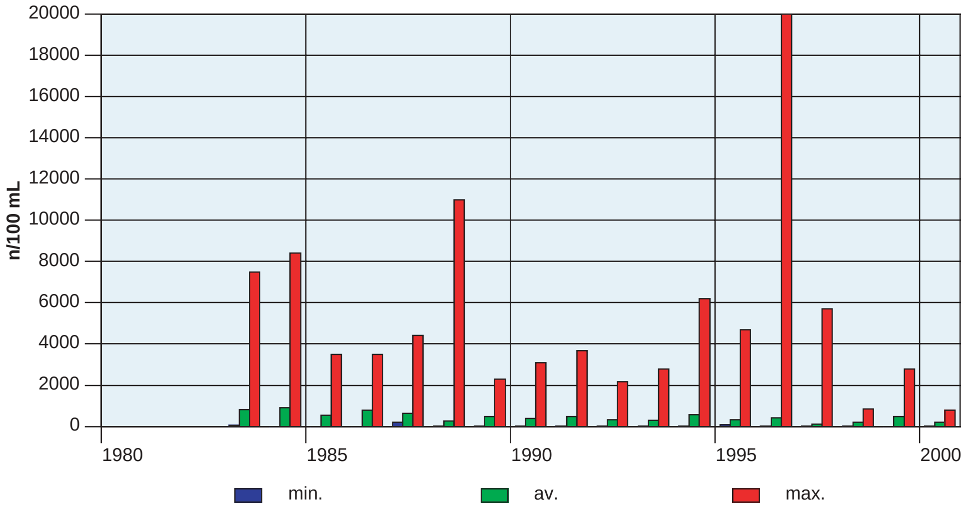
The faecal load of the Rhine water examined at Lobith was many times higher in 1999 and 2000, as well as in the previous years, than the faecal load of the IJsselmeer water in Andijk, the Haringvliet water in Stellendam and the Lek water in Nieuwegein. Nevertheless, the standards associated with the Netherlands quality objective "Surface water for drinking water preparation" were complied with for faecal streptococci (a median value of 10 KVE per ml) at all measuring locations, just as in previous years. The median values of the thermal tolerant bacteria of the coli group also met the standards associated with the Netherlands quality objective "Surface water for drinking water preparation" at all four measuring locations (20 KVE per ml).

Current problems

Diffuse discharges constitute a continuously increasing share of water pollution as the spot sources are remedied. From then on, the studies concentrate on groups of substances which were not given any attention or given very little attention in the past, such as substances with endocrinal effect, medications in water, fire retardants, laundry detergents, etc. Contaminating the surface water with pesticides and nutrients is a large bottleneck at the moment in the pursuit of ecological recovery.

As long as water companies are forced to stop taking in water due to the high concentrations of pesticides, the situation cannot be called satisfactory. In addition to domestic households and small industry, agriculture is perhaps the biggest polluter at the moment. It is true that the sector is using fewer kilos of pesticides than in the past, but due to the use of continuously more

Rhine water feacal streptococci at Lobith (1983-2000)



modern, more effective agents the water quality certainly did not improve in the same proportion.

The Rhine in the future

For many centuries, people have been working on the layout of the Rhine watershed. Natural landscape changed into cultural landscape, the flow was by and large dominated and the water meadows were used for agriculture and extraction of clay and sand. Due to this, the Rhine has lost a great deal of its natural behaviour and capacity to adapt, especially when processing high water surges are concerned. The chemical quality has improved in broad outlines, but there still are hundreds of substances which break down poorly and thus remain present in the rivers and their sediment.

Safety, also when discharges increase, remains the most important item, but will no longer be sought in higher dikes but rather in digging retention areas. Development of nature demands a better layout of the river area. Growing professional navigation in its turn demands adaptation of the shipping channels. Drinking water will be extracted from rivers to an increasing extent. Further improvement of the water quality is required for this, at least if the RIWA and IAWR requirements are met to only produce drinking water by means of natural purification methods.

The current water quality allows recovery and return of a number of plant and animal species, despite the fact that the limit values will not be complied with for all polluting substances. The nutrient load still poses problems for the IJsselmeer and the North Sea. The metal situation is stable. Some pesticides still exceed the standards, which is no longer an option. The International Rhine Commission, RIWA and IAWR will therefore also have to remain active in the future.

Raw material quality

3

Pesticides are still a problem

Since the middle of the eighties, pesticides have been part of the political agenda and in the past fifteen years numerous "new" substances were detected and reports were published about these all the time. This involved the old pesticides atrazine and bentazon and substitutes and successors glyphosphate (with AMPA as breakdown product) and diuron and numerous other pesticides.

Meanwhile, spot discharges have been reduced to an important extent due to actions by water companies, but the diffuse discharges of pesticides are still not a thing of the past. An example is the diuron concentration in the Meuse, which is still at an excessive level, and another example is isoproturon, which reaches critical values at times.

Smaller doses

An essential component of the problem is that the pesticides developed in the past fifteen years are all effective in much smaller doses. Moreover, these pesticides have another property in common: they are considerably more polar than older pesticides, in brief, they attach much better to water. This means that it is more difficult to pry them from the water phase, so it is more difficult to analyse them and purify them from the water.

"Hundreds of pesticides"

The RIZA report "Hundreds of pesticides; pesticides in surface water & floating matter measured by the harmonica model (1999)" was published. The report describes the "harmonica model" which can be used to implement an efficient and effective measuring program on the emission of diffuse sources, and describes a case study, in which the model is used for studying the presence of pesticides in surface water and floating matter of the Federal waterways. During different agricultural seasons in 1999, water and floating matter were sampled and analysed for 374 and 244 different substances, respectively, at seven location in the Federal waterways.

81 pesticides

A total of 106 substances were demonstrated to be present in the surface water, 81 of them pesticides. 65 of these are authorised as such in the Netherlands, Belgium or Germany, while 11 pesticides are prohibited in the Netherlands. At Keizersveer a number of substances have also been found which were not encountered at Eijsden, which points to extensive use in the Netherlands.

10 conversion products of pesticides were sought. Of the 8 which were demonstrated to be present, conversion products of dichlorobenil and atrazine occur most frequently. Finally, another 17 industrial contaminants were found, especially familiar compounds such as chlorobenzenes, the majority of which are already routinely analysed by RIZA.

MTR and drinking water standards

The results are tested to the maximum permissible risk (MTR) from the Fourth Water Economy Memorandum, and to the drinking water standard for pesticides (0.1 μg/l for individual pesticides or metabolites; 0.5 μg/l for the sum). Eight substances were found in a concentration exceeding the MTR; these were also found in more than 50% of the number of times the test was carried out. In three-quarters of the tests ten substances were measured in concentrations exceeding the drinking water standards for individual substances, while the sum standard was exceeded in 40% of the surveys. In total, it was established that one of the standards, at minimum, was exceeded in 71% of the surveys.

Floating matter

28 substances were shown to be present in floating matter, including 20 pesticides. Fifteen of these are authorised as such in the Netherlands, Belgium or Germany; five are prohibited in the Netherlands as well as in the surrounding countries. The opinion is offered that these substances may have been used in an application other than as a pesticide or were used illegally. The report makes it clear that we – despite all attention given to pesticides in the past fifteen years – have not nearly arrived at where we want to be.

Application of the immunoassay in water quality monitoring

Beginning a number of years ago, the N.V. Water transport company Rhine-Kennemerland, as part of intake monitoring, has used the immunoassay as detection and screening method for certain pesticides. The advantages of immunoassays are the speed of analysis (the result is generally known within three hours), the fact that pre-processing is usually not necessary, the multi-sample nature of the method (up to 44 samples in two copies per analysis run), the small volume of water sample necessary (e.g. 1 ml), the very high sensitivity (detection limits up to < 0,05 μg/l) and the low cost in comparison with the regular analysis methods.

Pesticides are especially suitable for this type of analysis, because it is difficult to analyse them via conventional chromatography. The advantage of speed and low cost is especially expressed when following pesticides which only appear during a – unpredictable and brief – period in the water in peak concentrations, such as herbicides which are only used in spring and/or fall in agriculture and urban greenbelt service.

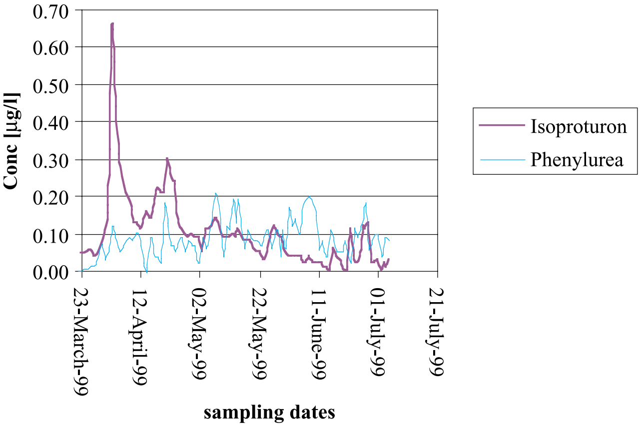
Applicability

WRK has published the applicability of the immunoassay in water quality inspection for 2,4-D from the beginning of the 90s. (2,4-dichlorophenoxy-acetic acid). Samples taken daily in the Rhine at Lobith were analysed for presence and concentration of 2,4-D. A peak concentration of 2,4-D was detected during that time which only appeared for less than a week, however. It became clear that the analysis results were available sufficiently rapidly in order to take measures concerning the intake of water for the drinking water production, if necessary. In the following years (1995-1999), the phenylurea herbicides were selected as the target compounds, because this group of pesticides is also utilised in large quantities in agriculture, mainly in the spring. Two different kits were used, and are still being used, for this test: a kit for isoproturon a kit which is highly specific and a kit for the group of phenylurea herbicides which detects diuron and chlorotoluron as the principal compounds.

In the months of March-June daily collective samples of Rhine water are taken at Lobith every year in co-operation with consultation agency ELTI in

Nijmegen, which, depending on the discharge and thus on the time it takes to the intake point at Nieuwegein, are measured in series periodically. In this way maximum advantage is taken of the multi-sample nature and the costs per sample are minimal, while the measurement results are nevertheless still available in time. An example of the results found in 1999 is presented below.

Concentrations of phenylurea herbicides and isoproturon measured by immunoassay (in µg/l)



Evaluation

Within the framework of a study initiated by the STOWA on indicative analytical methods for the quality of water, a number of immunoassay kits were evaluated and validated. Selected according to the presence of pesticides in the Netherlands surface water, kits were tested for triazines, phenylurea herbicides, isoproturon, cyclodienes and carbendazim. The final conclusion of this study was that the kits for isoproturon and carbendazim are very suitable for sensitive substance-specific detection/screening, while the other kits are suitable for the indicative screening for the group of pesticides referred to.

Further development

In summary, it may be stated that immunoassays and especially commercially available kits are eminently suitable for screening the presence of certain (groups) of pesticides and other environment-contaminating substances/micro-contaminations in surface water. Especially the speed of the analysis, the high sensitivity and the low costs present an advantage in comparison with the conventional analysis methods. One of the disadvantages of the kits available at the moment is the fact that a separate kit must be used for each substance or substance group, but within the framework of an EU project work is already being done on development of immunoassays which can determine the presence of several (groups) of pesticides in the same sample simultaneously.

***Cryptosporidium* and *Giardia* in the Rhine and Meuse**

In addition to contamination of anthropogenic origin, such as pesticides, there are natural threats to the water quality. An important group of these is made up of the pathogenic bacteria, viruses and also protozoa, of which the single-cell parasitic organisms *Cryptosporidium* and *Giardia* are considered as the most important causes of intestinal infections in humans and animals. In the chapter “published reports” we will discuss in more detail a large-scale study which was carried out in 1997 and 1998 on these parasites.

Removal capacity

In the concept of the new drinking water directive it is established that the risk of infection via drinking water may not exceed 1 per 10,000 persons per year. Based on these standards and the established concentrations of *Cryptosporidium* and *Giardia* in the surface water, the removal necessary during purification was examined. This amounts to 5.8 to 7.0 ^{10}log units for *Cryptosporidium* oö cysts and 6.0 to 7.8 ^{10}log units for *Giardia* cysts.

How effective is the purification for the removal of these parasites actually? Table 1 for H_2O (no. 23, 2000, 18-21) presents the removal capacity of various drinking water purification processes.

Table 1

Process	**Purification step**	**Elimination capacity in ^{10}log-units** *Giardia*	 *Cryptosporidium*
Disinfecting	Chlorine	0 – 2	0
	Chlorodioxide	0 – 1	0
	Ozone	1 – 4	0 – 1
	UV	2 – >4	2 – >4
Filtration	Quick-filtration	0 – 1	0 – 1
	Slow sand filtration	1 – >4	1 – >4
	Active carbon filtration	0 – 0.5	0 – 0.5
	Ultra filtration		>4 >4
	Coagulation/quick filtration	2 – 2.5	2 – 2.5
Soil passage	Dune infiltration		>4 >4
	Bank filtration	>2 – >5	>2 – >5
Reservoir storage		0.5 – 2	0.5 – 2

It was observed that chemical disinfection barely contributes to the removal of protozoa, but that UV disinfection causes considerable deactivation. Slow sand filtration and membrane filtration are effective, while coagulation combined with quick-filtration has a limited effectiveness. Removal by storage in reservoirs depends, among other things, on the time the water is stored (more effective as the period lengthens) and on the reservoir configuration.

No epidemics

No epidemics of *Cryptosporidium* and *Giardia* have occurred in the Netherlands as the result of infections via drinking water (a minor epidemic occurred in the mid-nineties as a result of contaminated swimming pool water). The explanation of proper protection against infection is found especially in the use of groundwater for two-thirds of our drinking water and the adequate purification of the surface water which is used for the preparation of drinking water. In the surface water sources the (oö)cysts of *Cryptosporidium* and *Giardia* occur in considerable quantities as a result of faecal contamination. In order to be safeguarded from infections in the future too, it is in any case important to also examine the system of purification at this point. In addition, actions focused on reducing the concentrations in the surface water are necessary. Further remediation of the discharge of domestic waste water in the rivers and reduction of the leaching of manure substances from agriculture are examples of this.

Horseradish, a brackish water plant (Photo: Jan v.d. Broeke, RIKZ)

Development in the Rhine watershed

4

Room for the Rhine

In the Rhine watershed, the best measures for anticipating the expected rise in sea level, increase in river discharge and sinking of the ground level, are vigorously sought. At Loevestein castle, at the end of February, 2000, the recommendations which are the result of the exploratory studies: “Room for Rhine tributaries” and “Integral Exploration of Lower Rivers” were presented to the government. In her response, assistant minister De Vries mentioned a few locations which could come under consideration as disaster polders. She caused a great deal of commotion among the unprepared regional and local administrators and the residents in these areas. Still, it is necessary to reserve space along the rivers in order to be able to absorb extremely high water levels by controlled flooding.

The explorations clearly show that the government is on the right track with the “Room for the Rivers” policy. If the correct measures are taken in the entire watershed in co-operation with the German authorities, the safety in the river area in the medium-long term (until 2050) is ensured. The condition is that the storage and discharge capacity in the winter bed cannot be altered. Capacity beyond the winter bed must also be sought for in the long term. In addition, a combination of measures outside and inside the dikes must be taken.

Plan study

In December 2000, the cabinet gave the green light for a plan study as a follow-up for the two explorations. The intention is that the current standard high water level in the upper rivers remains unchanged, even for a Rhine discharge of 16,000 m^3/s at Lobith. In concrete form, the order is to describe the measures necessary for this and which can be implemented between now and 2015. These must be so-called “no regrets measures”, meaning: measures which do not obstruct any follow-up measures that may have to be taken if the Rhine discharge would increase even more, e.g. up to 18,000 m^3/s.

An important topic of the study is the possible national re-distribution of the water discharge over the rivers. If the discharge distribution of the Rhine over the partial systems Waal, Lower Rhine or IJssel is altered this will have direct consequences on the lower rivers and the IJsselmeer. In turn, they must be able to discharge the additional water safely.

Changes in the climate will not only lead to higher discharge in the winter, but probably also to lower discharge in the summer. Those may even be extremely low. That problem also merits attention for lower Rhine discharge causes salinisation of the Holland IJssel and thus will have negative consequences for the fresh water provision in the Middle and Western Netherlands.

Tension

In August 2000, the “Water policy for the 21st century” recommendation from the 21st century Water Management Commission was published. The committee emphatically pointed out the necessity of a coherent vision on the principal water economy system. The recommendation was received with approval everywhere. As a consequence of that, the cabinet decided to have a study of this carried out rapidly, the Tension study. The results of this study should be available by the end of 2001, for then they can still be included in the plan study mentioned above.

International co-operation

The countries in the Rhine watershed have already made agreements about an integral approach of protection of the water system. The wish to retain the water in the system's capillaries as long as possible before it enters the main system has a central role in the approach. Because of this extremely high water levels will not occur so quickly. In addition the river must be given as much space as possible to limit the risk of flooding.

These measures are only effective if they are implemented throughout the entire watershed. Thus, co-operation at watershed level is very important and in fact has been taking place for many years already. For example, the province of Gelderland, the Federal Water Authority and the state of North Rhine-Westphalia signed an agreement in 1997 to synchronise operations in the area of high water protection. The parties convened again in February 2000 in the German city of Rees for the second high water conference. This is intended to become an annually recurring event.

The Netherlands contributes to German retention reservoir

The river demands space, but space is especially scarce in the densely populated Netherlands. Moreover, agricultural land is more expensive here than in the surrounding countries. From the viewpoint of cost effectiveness it is therefore better to approach the space problem at watershed level. In that case, it is a logical step for the Netherlands to contribute to the costs made upstream to use agricultural land for storing additional water discharge. In February 2000, an agreement was signed between the Netherlands and Germany for creating an 1100 hectare retention reservoir along the Rhine in North Rhine-Westphalia. The Netherlands is paying about half (21.2 million guilders) of this project, which cost a total of 46 million guilders.

IRMA program

Insofar as co-operation is concerned, the IRMA program (Interregional Rhine-Meuse activities) which expires in 2001 cannot remain unmentioned. More than 150 projects are being implemented in all countries of the Rhine and Meuse watersheds, more than half of them in the Netherlands. Among other things, this involves projects which restore the course of tributaries or measures in the winter bed. An example of a project being implemented is moving the Bakenhofse Dike at Arnhem 200 metres inland. This dike obstructs the free flow of the river. The 12-hectare water meadow which is created by moving the dike is laid out as a nature area and is part of the Main Ecological Structure. The costs of this project are more than 12 million euros. IRMA contributes nearly 6 million euros to this.

Another example of an IRMA project is the Lahor project: a model which predicts the effects of measures in the Rhine watershed. The development of this was begun in 1999. In the same year a new version was also made of the already existing Rhine alarm mode. This provides more insight into the speed at which the river transports substances.

International Rhine Commission

The International Rhine Commission had maps made of risk areas at high water. These play a role in campaigns for making the public at large in the

Rhine bank nations aware of the possible consequences of high water. This project is a follow-up of the Rhine High Water Action Plan.

In the high water plans the Rhine and Meuse bank nations have established that they will optimise the prediction periods of high water levels, among other things. The sooner it is known that a high water surge is on its way, the better precautionary measures can be taken, especially downstream. In 2000, the prediction period of the water levels of the Rhine at Lobith was extended to three days. The objective is to achieve a prediction period of four days by 2005. A five to six-day prediction period is even considered a possibility for the future.

Ecological recovery

It is not possible to call the ecological situation of the Rhine flourishing. In the NURG program (Further Elaboration of the River Area) is plotted on a time schedule for ecological recovery of the water meadows. By 2000, 3850 hectares or water meadows had been acquired in accordance with the plan. But the layout remains behind schedule. Only 1400 hectares have been worked on. That is because it takes a very long time before the plans are concluded. Contaminated soil also delay the process.

Within the NURG framework, many nature-friendly banks are being created. About 400 km of Rhine bank is free of rent. About 250 km of this is under nature-friendly management.

Water quality

In 2000 the International Rhine Commission reported on the emissions of nitrogen and phosphate in 1985 and 1996. A reduction target of 50 percent applies to both substances in the Rhine Action Program. Inventory involves both diffuse and point sources. The conclusion is that emissions of nitrogen have been reduced considerably by 26 percent as compared to 1985. But the objective in the Rhine Action Program was not achieved. The reduction was mainly due to a reduction of emissions from point sources: sewage plants and industry. The diffuse agricultural source is still a problem. Further reduction of nitrogen therefore remains an action point of the International Rhine Commission.

Total reduction of the emission of phosphate was 65 percent as compared to 1985. The reduction target for phosphate of the Rhine Action Program was thus amply achieved. This reduction is also mainly due to forcing back the point source emissions. But an excessive amount of phosphate as agricultural waste still enters the water.

Various PCB concentrations in the floating matter of the big rivers exceed the Maximum Permissible Risk (MTR). The NTR is the minimum quality which must be achieved in the short term. In addition, the target value has been established for many substances. That is the desirable long-term quality. The MTR is achieved, however, for some PAH in the floating matter (e.g. benz(a)pyrene), but for some others (e.g. anthracene) it is not.

Hexachlorobenzene poses a problem in the floating matter of the Rhine. Choline esterase inhibitors exceed the MTR in the big rivers at the borders with Belgium and Germany, but in the places where the Rhine enters the ocean, both the MTR and the target value have been satisfactorily achieved.

The salmon has returned

The program for the return of the salmon in the Rhine is developing successfully. A fish ladder was put into operation at the Iffezheim dam in the German Oberrhein in 2000. That was an important milestone in the “Salmon 2000” program. A number of spawning places are now accessible for salmonides as part of the Rhine system.

Milkwort thrives in brackish water (Photo: Jan v.d. Broeke, RIKZ)

5

Salt discharges in the Alsace: negotiations and legal procedures

During the first Rhine Conference of Ministers in October 1972, France made an agreement with the other Rhine bank nations that part of the waste salt from the potassium mines at Mulhouse (Alsace) would no longer be discharged in the Rhine but stored in the ground via salt injections. In 1980 it became clear that France did not intend to comply with this eight-year-old agreement. What took the cake was that in December 1980 the prefect of the French Haut-Rhin department extended the potassium mine permit to discharge the brine (water containing waste salt) into the Rhine via the Grand Alsace Canal. In response to this, ten Dutch agencies decided to attempt to reduce the salt load in the Rhine via administrative legislation. An administrative procedure was begun in Strasbourg in February 1981.

Verdict after 20 years

Twenty years later, on April 11, 2000 the administrative procedure led to a verdict which may be considered a break-through. The verdict was given on the basis of a few documents with very divergent backgrounds: on the one hand, correspondence with the French government at the end of 1987/beginning of 1988, on the other an expert report from the end of 1996/beginning of 1997, originating from a criminal proceeding. Part of the damage the salt had inflicted on the water system of two of the ten Dutch parties was compensated by the French state. A number of years before that international agreements had already accomplished that the salinity in the Rhine at the Dutch border, as a result of partial storage of the waste salt, would be limited, in any case, to 200 mg/l.

Termination of potassium production

At the moment, negotiations are being held about a possible termination of the current Rhine salt procedures and the potassium mines in the Alsace are making preparations to terminate potassium production in 2004. The following pages provide a summary on the international consequences of nearly one century of potassium production in the Alsace.

	Developments / International consultation		Civil procedure – horticulturist process
1904	The French Alsace is explored for salt layers to produce salt.	**1904**	
1910	- The first salt layer is found in the French Alsace. - Beginning of mine construction and potassium production in the Alsace.	**1910**	
1920	3,900 workers produce 203,000 tonnes of chemical fertiliser annually from the Alsace potassium mines. The waste product salt is stored in older mine shafts.	**1920**	
1931	- Construction of the 3rd factory on the premises of the Alsace potassium mines. - **April 24:** Prefect of Haut-Rhin grants the national potassium mining company **a permit for the first time** for discharging brine (water with waste salts) in the Rhine up to a maximum of 200 gram per m^3 of water. - Federal Drinking Water Agency: salt measurements at Lobith.	**1931**	
1932	The Netherlands protests in vain in Paris against the salt discharge.	**1932**	
1935	Until this year, 10 gigantic mountains of waste salt are produced in the Alsace, resulting in ground water salinisation.	**1935**	
	– Preamble to and occurrence of WW II –		**Preamble to and occurrence of WW II –**
1946	The industrial production is taken up with renewed spirit. Pollution of rivers and other surface water increases. (Rhine pollution: heavy metals, biocides and salt.)	**1946**	
1950	- **July 11:** Consultation is begun in Basel, at Dutch initiative, between the river-managing agencies of the Rhine bank nations, leading to the International Commission for the protection of the Rhine (IKSR). - **In 1950 MDPA* employed 12,700 workers. -**	**1950**	
1951	**June 15:** Four Dutch water companies found RIWA.	**1951**	
1953	IKSR begins Rhine water measurements at 8 sampling locations.	**1953**	
1963	**April 29:** Formalisation of IKSR by means of the Treaty of Bern. Consultation authorisation; veto right limits decision making.	**1963**	
1965	**May 1:** The Treaty of Bern takes effect (D, F, L, NL, CH).	**1965**	
1966	**August 9:** Prefect of Haut-Rhin grants MDPA a discharge permit until December 31, 1970 (discharge via the Grand Alsace Canal).	**1966**	
1970	Oxygen economy of the Rhine improves, the concentration of heavy metals decreases considerably, the salt concentration does not change.	**1970**	
1972	**October 25-26:** 1st Rhine Conference of Ministers, The Hague. The first agreements are made regarding storage of 60 kg/s chlorine ions in the Alsace, starting no later than January 1975. (Total potassium discharge in 1972 is ±130 kg/s (36% of the Rhine salt load).	**1972**	
1973	December 4-5: 2nd Rhine Conference of Ministers, Bonn. Especially focuses on chemical and thermal pollution and the Rhine remediation plan.	**1973**	
1974		**1974**	With the objective of being able to begin a civil procedure (by the Environmental Defence Association) the Stichting Reinwater (Clean Water Foundation) is founded. **October 4: Civil procedure is begun.** **Demand:** damage compensation due to unlawful salt discharge. **Plaintiffs:** Stichting Reinwater, horticulturist Bier (the Westland). **Defendant:** potassium mines (MDPA), Mulhouse (Alsace). **Location:** Rotterdam District Court. **October 4: Civil procedure is begun.** A similar damage claim due to salt discharge. **Plaintiffs:** horticulturists Strik and Valstar (Aalsmeer). **Defendant:** potassium mines (MDPA), Mulhouse (Alsace). **Location:** Court of The Hague.

*MDPA=Mines de Potasse d'Alsace

	Developments / International consultation		Civil procedure – horticulturist process
1975	In accordance with the 1st Rhine Conference of Ministers, salt storage **does not begin on January 1**, 1975.	**1975**	**May 12:** The Rotterdam court declares itself incompetent and considers the place of discharge more appropriate than the place of damage. The plaintiffs appeal to The Hague Court, which submits the question of competence to the (EEC) Court of Justice in Luxembourg.
1976	- **March 31:** Closure of buffer reservoirs in Fessenheim (Baden-Württemberg) due to ground salinisation. Consequences for the salt concentration in the Rhine. - **March 31:** Prefect of Haut-Rhin grants MDPA a discharge permit until December 31, 1980 (annual average 130 kg/s). - **April 1:** 3rd Rhine Conference of Ministers, Paris. Agreement on the Rhine Chemistry Treaty. Setting the date for the 4th Rhine Conference of Ministers about salt. - **May 25:** 4th Rhine Conference of Ministers, Bern. Agreement on the Rhine Salt Treaty. Storage of 20 kg/s, 40 kg/s, 60 kg/s (2-year phases). (60 kg/s can thus be attained before January 1980) - **December 3:** Signing in Bonn of the Rhine Salt Treaty, among other things.	**1976**	**November 30:** The Court of Justice considers both places appropriate.
1977		**1977**	- **June 7:** The Court of The Hague nullifies the decision of the Rotterdam Court and sends the case back to the Rotterdam Court. - **November 21:** Rotterdam combines the horticulturist cases.
1978	- **July:** salt injection preparations appeared to have been postponed. - Ratification of the Salt Treaty in the Assemblée Nationale is taken off the agenda every time due to fear of rejection.	**1978**	
1979	**December 5-6:** The French government removes the Rhine Salt Treaty bill from the agenda of the Assemblée. The Dutch ambassador is recalled from Paris.	**1979**	**January 8:** The Rotterdam Court declares the Reinwater case inadmissible. The horticulturists continue, supported by Reinwater. (Central point: proving damage by which water?: Rhine, ocean, other). At the interim verdict: appearance of the parties.
1980	- Salt problem: France proposes construction of 2 domestic salt factories; investment via salt treaty distribution key. This meets with resistance from the Lorrain salt industry and the Rhine nations: excess capacity. - IKSR inventories 12 possible solutions to the salt problem. - **December 22:** Prefect of Haut-Rhin extends the permit for the potassium mines unaltered until December 31, 1981.	**1980**	- **April 28:** 3 independent experts are appointed: how much salt in the water system originates in the potassium mines? - **November 24:** The Rotterdam Court swears in experts Van der Molen (NL), Ruellan (F) and Van der Beken (B). The expert report must be handed in before September 1981. Commentary from the parties on the case will be processed in the definitive report.

	Administrative procedure - 10 parties		Criminal proceedings - 10 parties		Civil procedure - 2 parties
1975		**1975**		**1975**	
1976		**1976**		**1976**	
1977		**1977**		**1977**	
1978		**1978**		**1978**	
1979		**1979**		**1979**	
1980	- **December 22:** RIWA initiates an opinion poll among the Alsace residents about possible objections to salt injections. (605 persons interviewed: 49% no objections, 28% object). - Preparation of a petition against extending the discharge permit by RIWA and VEWIN, with 8 other parties joining them.	**1980**		**1980**	

	Developments / International consultation		Civil procedure – horticulturist process
1981	**January 26:** 5th Rhine Conference of Ministers, Wassenaar. Discussion of the problem of France not ratifying the Rhine Salt Treaty.	**1981**	
	March 18: Prefect of Haut-Rhin repeals the permit extension and grants a permit that was somewhat modified; this one until December 31, 1990.		
	November 17: 6th Rhine Conference of Ministers, Paris. France is requested to find a solution for the salt problem.		**2nd half of 1981:** The experts send the report to the parties involved in the case for their commentary.
1982	- **December 7:** Paris: Prime Ministers Lubbers & Mauroy discuss the salt problem: in the spring of 1983, the Salt Treaty is submitted to the Assemblée for ratification. After 1.5 years there will be a 20 kg/s salt injection. - **December 9:** IRC delegation leaders do not succeed in setting up a firm time schedule to reduce the potassium mine salt discharges.	**1982**	**April 22:** Definitive expert report is sent to the Rotterdam Court (8 months later than agreed upon).
1983	**April 29-May 4:** Exchange of letters between the NL-F governments about adapting the 1976 Rhine Salt Treaty: a different location for salt injection (F-BRD border) 1.5 after the treaty takes effect; 2nd phase (40 kg/s) after 3.5 years. **August 4:** Prefect of Haut-Rhin grants the potassium mines a temporary permit (mise en demeure), without being requested to do so, this time with an unlimited period of validity (but with the obligation to request a new permit before a certain date).	**1983**	
	October 7: The Assemblée ratifies the Rhine Salt Treaty Bill including additional exchange of letters in April-May 1983.		
	November 10: The French Senate also ratifies the salt treaty.		
	- **In 1983, MDPA reduces the number of its workers to 5,600.00 by means of automation/mechanisation. -**		**December 16:** Verdict from the Rotterdam District Court: the potassium mine discharge is unlawful; they must pay damage compensation for the salinisation of the sprinkler water of the horticulturists from 1-1-75 + the court costs.

	Administrative procedure - 10 parties		Criminal proceedings - 10 parties		Civil procedure - 2 parties
1981 **A1**	Prior to an administrative lawsuit, consultation takes place with Ministries of Foreign Affairs and Transportation and Public Works, who concur with the lawsuit. **18 February: Administrative lawsuit is begun. Petition:** against 12-22-1980 salt discharge permit. **Plaintiffs:** 10 NL government agencies and organisations: the province of N-H, City of Amsterdam, VEWIN, RIWA, Stichting Reinwater, WRK, Delfland, Rijnland Water Authorities, Ministries of Foreign Affairs and Transportation and Public Works, Schieland, Rivierenland Z.schap. **Attorneys:** Christian Huglo & Corinne Lepage Jessua. **Location:** Tribunal Administratif, Strasbourg (French administrative or governmental court, Strasbourg).	**1981**		**1981**	
A1	**May 6:** The plaintiffs submit a new petition of appeal, adapted to the modified discharge permit of March 18, 1981.				
1982		**1982**		**1982**	
1983		**1983**		**1983**	
A1	**July 27:** Tribunal Administratif Verdict: the December 22, 1980 and March 18, 1981 discharge permits are nullified.				
A2	- **August 10:** Petition of appeal by the NL parties at the Tribunal Administratif of the August 4, 1983 interim permit. - NL parties also submit a complaint about improper government at the Appeals Commission of Conseil d'Etat.				
A1	**- September:** appeal by the potassium mines at the Conseil d'Etat (State Council), Paris, of the 7-27-1983 Tribunal Administratif verdict.		**October 7: Beginning of the criminal proceedings. Damage claim:** infringement by discharging without a permit (not complying with legal regulations for special industries (installations classées). **Re:** periods during which consecutive permits were granted which were later nullified; **a)** period 1981-1983, **b)** extended on 8-13-1986 to the period 1980-1986. **Demand:** damage compensation. **Plaintiffs:** 10 NL government agencies and organisations: the province of N-H, City of Amsterdam, VEWIN, RIWA, Stichting Reinwater, WRK, Delfland, Rijnland, Schieland, Rivierenland Z.schap. **Defendant(s):** (the consecutive) MDPA director(s) during the period(s) in question (see above). **Location:** Tribunal de Grande Instance (district court), Mulhouse.		

	Developments / International consultation		Civil procedure – horticulturist process
1984	**May 15:** ratification by Luxembourg of the addition to the 1983 Rhine Salt Treaty. **- July 2: Prefect grants a permit for exploratory drilling at Chalampé** - Chalampé appeals the permit at the Trib. Administratif. - **November 6:** Trib. Adm. rejects the Chalampé appeal. - **December 14:** Ratification by Germany of the addition to the 1983 Rhine Salt Treaty.	**1984**	**March 15:** Appeal by potassium mines of the 1-8-1979, 4-28-1980 and 12-16-1983 verdicts at the Court in The Hague. **December:** Appeal: potassium mines submit a memorandum of grievances.
1985	**July 5:** Ratification by the Netherlands of the addition to the 1983 Rhine Salt Treaty. The Rhine Salt Treaty takes effect in 1976 including 1983 addition. - **September 5:** Prefect of Haut-Rhin grants the potassium mines a new discharge permit until 2000. The discharge is continued until the Prefect gives instructions about reductions in accordance with the salt treaty. **- New investments in potassium mines in 1985 despite statement from Marchant that the potassium mines will close in the near future.**	**1985**	
1986	**March:** GWA dune filtration is only 30% of the normal quantity due to the high salt concentration in the Rhine as a result of low water discharge. **April 26:** Chernobyl nuclear reactor accident affects large areas in Europe.	**1986**	**March 19:** Pleas entered at the Hague Court in appeal by the potassium mines of the 16 December, 1983 verdict.

	Administrative procedure - 10 parties		Criminal proceedings - 10 parties		Civil procedure - 2 parties
1984		**1984**		**1984**	
			June 7: Procureur de la République appeals the damage claim of October 7, 1983 at the Tribunal de Grande Instance.		
			August 30: Conclusion submitted by 10 NL plaintiffs in connection with the solicitor's appeal; also submitted the City of Amsterdam GW-interests memorandum (damage memo submitted by the Province of Noord-Holland in 1985).		
1985		**1985**	- **February 19:** The Judge of Instruction, Mulhouse, admits the October 7, 1983 damage claim by the 10 NL plaintiffs *(re: legal preliminary investigation of the damage claim).*	**1985**	
A2	**February 21:** The Appeals Commission Conseil d'Etat considers the complaint (8-10-1983 – improper management) as settled. The Prefect of Haut-Rhin had obligated the potassium mines to request a new discharge permit AND to draw up an environmental impact report on the consequences of the salt discharge.		- **February 20:** The la République solicitor appeals the declaration of admission at the Chambre d'Accusation (legal preliminary investigation control for criminal cases) de la Cour d'Appel, Colmar.		
			- **April 11:** the Cour d'Appel agrees to decide the appeal by France.		
			- **June 6:** Chambre d'Accusation does not admit the claim by 4 private law plaintiffs (RIWA, VEWIN, WRK, Reinwater). The damage claim investigation will be continued (6 parties admitted).		
			- **June 11:** appeal by the plaintiffs of the non-admissible declaration at the Cour de Cassation (Court of Cassation), Chambre Criminelle, Paris.		
A3	**November 5:** appeal by NL parties (petition of appeal) at the Tribunal Administratif of the September 5, 1985 discharge permits.				
1986		**1986**		**1986**	
A1	**April 18:** Conseil d'Etat confirms at the highest level the (favourable) July 27 1983 verdict by the Tribunal Administratif *(re: the potassium mine appeal of this):* the 3-18-1981 permit was justifiably nullified.				
A1	**CONCLUDED: the 18 March, 1981 permit (issued May 6, 1981).**				
			May 4-9: Visit from the Judge of Instruction (Schiele) and 2 French experts (Meyer and Weber) to the Netherlands with respect to the damage claim at the Tribunal de Grande Instance.		
A2	- **May 22:** The Tribunal Administratif rejects the complaint by the NL plaintiffs against the interim permit (mise en demeure) of August 4, 1983.				
A2	- Appeal by the NL plaintiffs at the Conseil d'Etat, Paris, of the May 22, 1986 Tribunal Administratif verdict on the interim permit (mise en demeure) of August 4, 1983.				

	Developments / International consultation		Civil procedure – horticulturist process
1986 continued	**October:** Announcement from France: salt will be stored from 1987 on at 20 kg/s. - **November 1:** Sandoz, Schweizerhalle fire. The consequences of this Rhine disaster push the salt problem to the second level. - **November 12:** Rhine bank nation minister meeting, Zürich, prompted by the Sandoz disaster: date and propositions for the Rhine conference. - **December 11:** Delegation leader consultation, Brussels (with regard to IKSR and salt). Salt injection is not possible. Salt will have to be stored above-ground. - **December 19:** 7th Rhine Conference of Ministers, Rotterdam. Safety/recovery measures; IRC Rhine Action Program (RAP) order.	**1986** continued	**September 10:** The potassium mines appeal at the Court in the Hague. The Court also upholds the Rotterdam Court verdicts. The potassium mines appeal at the Court of Cassation in the Hague. *Data: pleas entered on March 11, 1988/verdict before the end of 1988.)*
1987	**starting January 5:** 15 kg/s potassium mine salt storage (5% of the Rhine salt load) *(after more than 10-year delay).* **October 1:** 8th Rhine Conference of Ministers, Strasbourg, especially with respect to Sandoz and the Rhine Action Program (RAP). **December 29:** A letter with complaint from NL parties sent to Prime Minister Chirac (and the ministers of the Environment and Industry) about the state of affairs in the Rhine processes, with a request for damage compensation. *(The letter lists the damage per year: Amsterdam + N.H. 3.5 million French francs, water authorities 350,000 French francs, other parties (including RIWA) 100,000 French francs)* **- Potassium mines suffer a loss of 160 million guilders in 1987. -**	**1987**	
1988	**February 23:** Response from the minister of the Environment to the letter of December 29; he rejects the request for damage compensation (also on behalf of Prime Minister Chirac and the minister of Industry).	**1988**	**March 11:** Pleas at the Court of Cassation regarding the appeal of the potassium mines concerning the Hague Court verdict September 10, 1986.

	Administrative procedure - 10 parties		Criminal proceedings - 10 parties		Civil procedure - 2 parties
1986 continued		**1986** continued	- **July 10:** Favourable verdict from the Chambre d'Accusation, Colmar, (after new resistance by the solicitor): the claim by all 10 NL parties in the criminal proceedings was admitted by the Tribunal de Grande Instance. *(This independent from the appeal at the Cour de Cassation (Court of Cassation), Paris).* - **August 13:** The 10 NL parties increase their time period (extension of the period the infringements took place) of the damage claim from 10-7-1983. An additional security deposit of 25,000 French francs is required. *(= so-called 2nd damage claim of September 1986).* - **October:** Report of 2 experts (Meyer and Weber) received which discusses the effects from the salt load and damage to the NL plaintiffs (damage claim).	**1986** continued	
1987 A3 A3	**November 23:** Defence by the French minister of the Environment related to the 11-5-1985 petition of appeal by the NL parties of the discharge permit of September 5, 1985. **December 29:** Defence by the potassium mines related to the petition of appeal of the discharge permit of September 5, 1985.	**1987**	**June 23:** Cour de Cassation (Court of Cassation), Chambre Criminelle, Paris, nullifies the June 6, 1985 verdict and declares all NL parties admissible insofar as related to the July 19, 1976 legislation of legal action on the use of discharge installations. The case is referred to the Chambre d'Accusation de la Cour d'Appel, Paris. **December 3:** At the request of the Dutch parties, the French bailiff summons the la République solicitor to no longer block access to the dossier on the damage claim.	**1987**	
1988 A4	**April 25:** request by the 10 NL plaintiffs at the Tribunal Administratif to nullify the decision of the 3 French ministers and grant N-H and Amsterdam damage compensation of 25 million guilders over the period 1976-1987, among other things for continually granting the potassium mines new discharge permits *(See 12-29-1987 letters and 2-23-1988 column "Developments / International consultation". See also the expert report (1997) from the criminal proceedings. Both components combined lead to a favourable verdict by the Tribunal Administratif on April 11, 2000.)*	**1988**	**March 4:** The la République solicitor is summoned with respect to the 2nd damage claim of September 1986. **March 17:** Judge of Instruction Claviere Schiele is appointed. **May 17:** Cour d'Appel (Court of Justice), Paris declares that all NL parties are admitted in the 10-7-1983 damage claim). The potassium mines did not observe the legislation on legal action concerning the use of discharge installations. *(concerns inspection of the preliminary investigation in the criminal case)*	**1988**	

	Developments / International consultation		Civil procedure – horticulturist process
1988 continued	**October 11:** 9th Conference of Ministers, Bonn. French plan presentation 2nd phase of the treaty (storage of 40 kg/s) per 1-5-1989 and for study until 1995 for possible other solutions. Smit-Kroes: - priority of the Rhine Salt Treaty is lower with respect to other contaminations - contributing to storage of salt is unacceptable (only a delay of discharge). Implementation of the 2nd phase is suspended as of 1-5-1989 because of this. **- Potassium mines suffer a loss of 75 million guilders in 1988. -**	**1988** continued	**September 8:** In order to avoid going to court to determine the extent of damage, the 3 horticulturists sign a settlement with the potassium mines, which pay a sum of 3.75 million guilders. **September 23:** The Court of Cassation upholds the Court's decision and confirms the Rotterdam verdict of December 16, 1983. **CONCLUDED: civil horticulturist procedure (begun on October 4, 1974).**
1989	**June 22:** Prefect of Haut-Rhin grants the potassium mines a new discharge permit (115 kg/s instead of the max. annual average of 130 kg/s). *(presumably anticipating the nullification of the permit of September 5, 1985 by the Tribunal Administratif on August 3, 1989.)* **November 30:** 10th Rhine Conference of Ministers, Brussels. NL propositions (Maij-Weggen): regulation at Lobith of 200 mg/l; Wieringermeer diversion. (order to IRC: elaboration of Rhine Salt Treaty modifications). **- Potassium mines suffer a loss of 160 million guilders in 1989.-**	**1989**	
1990	- Now that the 2nd phase of the Rhine Salt Treaty will have a different content and the 3rd phase will definitely be implemented, the Netherlands and the IRC are deliberating about the **1)** 200 mg/l-regulation, **2)** technical and financial means for the seepage discharge of the Wieringermeer. - **October 1:** PWN is privatised into an N.V. and assumes the rights and obligations of the Province of North Holland in the salt procedures.	**1990**	

	Administrative procedure - 10 parties	Criminal proceedings - 10 parties	Civil procedure - 2 parties
1988 continued			**June 17: Injunction (Référé).** (Simplified procedure while awaiting a definitive verdict in the criminal proceedings). **Demand:** 4 million French francs (first damage compensation instalment) and request for assessment of the damage to the water system. **Plaintiffs:** 2 NL parties: Province of Noord-Holland & the City of Amsterdam. **Defendant:** potassium mines (MDPA) Alsace. **Location:** Tribunal de Grande Instance (district court), Mulhouse. **September 2:** Tribunal de Grande Instance awards provisional damage compensation (N-H 1.5 million French francs/Amsterdam 0.5 million French francs) and orders an investigation of the GWA and PWN damage by corrosion of the pipes due to salt discharge by the potassium mines. The potassium mines appeal the September 2, 1988 verdict at the Cour d'Appel, Colmar, about provisional damage compensation. - **November 7:** Cour d'Appel, Colmar, potassium mine appeal: nullification of the provisional damage compensation and damage investigation. - **December:** Cassation N-H and Amsterdam at the Cour de Cassation (Cassation Court) Paris, against the Colmar verdict of 11-7-1988.
1989	A3 **June 8:** Tribunal Administratif hearing. Strasbourg related to nullification of the 5 September, 1985, discharge permit demanded by the NL plaintiffs. A3 **August 3:** appeal by the NL parties of the 9-5-1985 permit. The Tribunal Administratif nullifies the September 5, 1985 discharge permit. *(MER insufficiently described the effects on the Netherlands from the discharge.)* A3 Appeal by the potassium mines at the Conseil d'Etat, Paris, of nullification of the September 5, 1985 permit by the Tribunal Administratif on August 3, 1989. A5 **December 29:** appeal by NL parties at the Tribunal Administratif of the new June 22, 1989 discharge permit.		
1990	A2 **October 15:** Conseil d'Etat confirms the Tribunal Administratif rejection of the complaint by the NL plaintiffs to the interim permit (…) of August 4, 1983 (motivation: serious economic and social problems if the production of the potassium mines were halted!) A2 **CONCLUDED: 8-4-1983 interim permit (initiated on 8-10-1983).**	**December:** Judge of Instruction Schiele urges the NL parties to make a decision on a new damage assessment. The 1986 report was made without involvement of the potassium mines; MDPA also has an expert now.	**October 29:** Cour de Cassation (Court of Cassation) rejects the cassation appeal by N-H and Amsterdam against the Cour d'Appel, Colmar, verdict which rejects damage compensation and damage investigation. (the report did not sufficiently demonstrate the relation discharge-corrosion.) **CONCLUDED: injunction N-H + Amsterdam (initiated 9-2-1988).**

	Developments / International consultation		Civil procedure – horticulturist process
1991	- **September 25:** Signing of the Supplemental Rhine Salt Treaty Protocol, Brussels: **a)** regulation of 200 mg/l-concentration at Lobith, **b)** Wieringermeer seepage discharge (32.37 million guilders), **c)** post-ponement of discharge of salt in storage (total 170 million guilders). - **October:** MDPA makes preparations for the storage of salt. - **November 1:** The NL parties deliberate about **a)** continuation or **b)** halting the procedures (administrative and criminal proceedings) or **c)** settling with the potassium mines. That there may be less chance of success due to the Supplemental Protocol is taken into account.	**1991**	
1992	- **March 22:** The 10 NL parties will only decide on whether the procedures will be continued after the Supplemental Protocol has been signed.	**1992**	
1993	- **February 25:** Switzerland and France ratify the Supplemental Protocol included in the Rhine Salt Treaty. - **spring:** Preparations of storage of salt concluded at MDPA. France ratifies the Supplemental Protocol. - **June 2-4:** RIWA delegation visit to MDPA, Alsace.	**1993**	
1994	**January 13:** Prefect of Haut-Rhin grants the potassium mines a new permit for discharging waste salts. **April 20:** Luxembourg ratifies the Supplemental Protocol. - **August 25:** The Netherlands ratify the Supplemental Protocol. - **September 15:** Germany is the last party to ratify the Supplemental Protocol included in the Rhine Salt Treaty. - **September 25:** official deadline for ratifying the Supplemental Protocol. **November 1:** The Supplemental Protocol takes effect. **December 8:** 11th Rhine minister conference, Bern; 3rd RAP phase.	**1994**	

	Administrative procedure - 10 parties		Criminal proceedings - 10 parties		Civil procedure - 2 parties
1991		**1991**		**1991**	
1992		**1992**		**1992**	
1993		**1993**	**beginning of 1993:** New Judge of Instruction Maman appointed. - **July 28:** Judge of Instruction Maman appoints 2 experts: Flaugnatti (contamination) and Le Gentil (damage estimate). **a)** The report will have to demonstrate a cause-and-effect relation between the salt discharge and the damage from corrosion. **b)** The report may be challenged by either party. - **October:** MDPA visit from experts Flaugnatti and Le Gentil. - **October 28:** Judge of Instruction Maman decides to have a rogatory commission investigation initiated (in cooperation with public prosecutor Botman).	**1993**	
1994 **A4**	**April 11:** memorandum of response by the NL parties with respect to assignment of damage compensation as well as legal fees. The claim is raised to 48 million guilders.	**1994**		**1994**	
A3	- **June 14:** request by the potassium mines to repeal the appeal at the Conseil d'Etat.				
A5	- **June 22:** Continuation of the appeal by NL parties at the Tribunal Administratif of the most recently granted June 22, 1989 discharge permit. *(The criminal proceedings report may also be used in this lawsuit.)*				
A5	**October 4:** A verdict on the June 22, 1989 discharge permit will not be forthcoming, because a new permit was granted on January 13, 1994. France will pay the NL parties 10,000 French francs because the procedure was lawfully begun at the time. **CONCLUDED: 6-22-1989 permit (initiated 12-29-1989).**				
A3	**November 2:** repeal of the appeal by the potassium mines at the Conseil d'Etat of the nullification of the 9-5-1985 permit by the Tribunal Administratif. **CONCLUDED: 9-5-1985 permit (initiated on August 3, 1989).**		**November 17-18:** 2 French experts visit the Netherlands. NL experts Oudshoorn and Schultze are appointed to assist. Questions related to the selection of sampling locations and the quality of the GWA and PWN pipe system.		

	Developments / International consultation		Civil procedure – horticulturist process
1995	**November 7:** Corinne Lepage is appointed minister of the environment in the Juppé cabinet. Huglo transfers procedures to Choucroy. *(Huglo & Lepage are partners in a law firm and in marriage.)*	**1995**	
1996		**1996**	
1997	**June 3:** Corrine Lepage steps down as minister of the Environment along with the other members of the Juppé Cabinet. Huglo will handle the procedures himself again. **November 24:** The Wieringermeer Excess Water Discharge into the Waddenzee is put into operation (cost: 41.7 million guilders).	**1997**	
1998	**January 22:** 12th Rhine Conference of Ministers, Rotterdam. High water problems, biotope network, new Rhine Treaty design (groundwater is also included in the objectives). **beginning of 1998:** memo from the French delegation to the IKSR: due to the high Rhine discharge since 1991 (Supplemental Protocol), the storage of salt was restricted to 833,300 tonnes through 1997. MDPA will maintain potassium production until sometime in 2004. There is a proposal to extend the Supplemental Protocol for 5 years (through 2004) with additional financing. - **December 31:** Expiration date of the Supplemental Salt Treaty Protocol.	**1998**	
1999	- **from 1999 on:** Large mountains of waste salt on the MDPA terrain are led into the Rhine in a modulated manner by means of spraying. - **April 12:** The New Rhine Treaty, related to objectives, principles, obligations, organisation, etc., of the IKSR is signed. - **July 6-7:** An agreement is made within IKSR that the modulated salt storage will continue, despite the expiration of the Supplemental Protocol.	**1999**	

	Administrative procedure - 10 → 2 parties		Criminal proceedings - 10 parties		Civil procedure - 2 parties
1995		**1995**	- **January 4:** Written questions from the 2 French experts. - **all of 1995:** The NL parties are busy answering all questions from experts Flaugnatti and Le Gentil.	**1995**	
1996		**1996**	- **January:** answers from the NL parties are sent, accompanied by argumentation by their lawyer, to the 2 French experts. - **December 30:** the expert report is sent to Judge Maman.	**1996**	
1997	**fall 1997:** Administrative judge inquires about the state of affairs in the criminal proceedings and the civil procedure.	**1997**	- **January 13:** the expert report is sent to the NL parties for commentary by March 15, 1997. Recommended 1980-1983 damage claims: PWN NLG 1,036,560/GWA NLG 1,340,186. 1983-1986 period damage compensation GWA NLG 1,420,597. Total damage compensation: NLG 3,797,343 (3.8 million guilders). - **April 25:** deadline for the potassium mines' commentary on the report. *(MDPA does not see any reason for counter-assessment, does not want to settle either, so follows the NL plaintiffs' damage claim via the civil court procedure.)* - **August 25-26:** With respect to the new legislation, Judge of Instruction Maman (Tribunal de Grande Instance, Paris) releases directors Greif and Marchand, respectively, from legal prosecution. - NL parties appeal the August 25-26, 1997 verdicts at the Chambre d'Accusation de la Cour d'Appel, Paris.	**1997**	
1998		**1998**	**February 16:** Chambre d'Accusation de la Cour d'Appel, Paris, rejects the criminal proceedings; the directorate cannot be prosecuted. **CONCLUDED: criminal proceedings against the MDPA directorate (initiated 10-7-1983).**	**1998**	**August 5: Beginning of civil procedure.** **Demand:** 33 million French francs (Amsterdam 16.5 million/PWN 16.5 million). **Re:** Potassium mines do not pay attention to laws to limit the damage caused to others by salt discharge. **Period:** 1980-1986. **Plaintiffs:** 2 NL parties: PWN and Amsterdam. **Defendant:** Potassium mines (MDPA), Alsace. *(the expert report in the criminal proceedings presumably plays a role.)* **Location:** Tribunal de Grande Instance (district court), Mulhouse.
1999		**1999**		**1999**	***December: Civil suit*** *against MDPA is postponed (initiated 8-5-1998) because the 4-25-1988 Administrative Procedure is going well all of a sudden and more can be expected from it.*

	Developments / International consultation		Civil procedure – horticulturist process
2000	**June 29:** European ministers of Environment and the European Parliament reach an agreement on the European Water Framework Directive. - **July 10:** Fish ladder (Europe's biggest) at Iffezheim is put into operation. - **July 11-12:** IKSR celebrates its 50th anniversary. - **December 22:** The European Water Policy Framework Directive (2000/60/EG) takes effect. - **end of 2000:** The Rhine Action Program (RAP) and the "Salmon 2000" program expire (both were begun after the 11-1-1986 Sandoz disaster).	**2000**	
2001	- **January 29:** 13th Rhine Conference of Ministers, Strasbourg. High Water Action Plan 2nd phase, durable development of the Rhine until 2020, water shed management (Rhine) according to the European Water Framework Directive. - **starting February:** France and the two remaining NL parties (PWN and Amsterdam) negotiate about the possibility of a settlement and termination of both the administrative and civil procedures.	**2001**	
2004	The presumable closing of the potassium mines in the Alsace in that year does not yet mean that an end will come to 73 years of salt discharge into the Rhine in the Alsace (since 1931). The waste salt, stored on MDPA terrain in big mountains, will be discharged in a modulated way into the Rhine for a long time yet (up to concentrations of 200 mg/l at Lobith).	**2004**	

	Administrative procedure - 2 parties		Criminal proceedings - 10 parties		Civil procedure - 2 parties
2000 **A4**	- **March 6:** in order to simplify further court procedures, the April 25, 1988 demand for damage compensation is repealed by all NL parties except PWN and Amsterdam. - **March 10:** Tribunal Administratif hearing related to damage compensation to PWN and Amsterdam and nullification of the negative decision of the 3 French ministers of February 23, 1988. (Tribunal Administratif: président – Mrs. D. Mazzega, conseillers – Messrs Pommier and Prioleaud.) - **April 11:** Favourable verdict by the Tribunal Administratif related to the claim by PWN and Amsterdam, of which 20% is paid. France is sentenced to pay 24 million French francs to PWN (NLG 4,936,186) and Amsterdam (NLG 3,028,906) *(including interest since April 1988 totalling 47 million French francs; at the beginning of 2001 this has accumulated to a sum of approx. 50 million French francs).* Appeal by the French State is possible until June 12, 2000. *(The verdict will possibly be inserted into the civil procedure.)* - **June 7:** France appeals at the Court in Nancy and requests suspension of the payment obligation. - **end August:** in order to end the accumulation of the interest, France, despite its appeal, proceeds to pay the damage compensation to PWN and Amsterdam anyway.	**2000**		**2000**	
2001	**January 18:** PWN and Amsterdam together receive an amount of 50 million French francs from the French State.	**2001**		**2001**	
2004		**2004**		**2004**	

Eelgrass grows on shallows that do not rise above the sea level at low tide, in creeks and brackish ponds closed off from the ocean

(Photo: Marieke van Katwijk)

“External integration” of water management

6

The Tielrooij Commission and the results of change in climate

In addition to the qualitative aspects, which were discussed in the previous chapters, we also are faced with quantitative developments in the Rhine and Meuse watershed that require our attention.

The big international conference on the climate policy and the greenhouse effect, in the Hague in November 2000, lacked results because the delegations could not agree on the manner in which the CO2 reduction could be settled and the follow-up conference in Berlin is also under heavy pressure now that the American president Bush shows little enthusiasm to even ratify the Kyoto climate treaty. Not everyone is as yet convinced of the nature and seriousness of the problem. But it is clear that our country in the delta must seriously take the consequences of climate change and sea level rising into account.

Higher temperature

The most probable scenario seems to be that the average temperature on earth will rise due to the greenhouse effect. (A possible consequence, the change of the global pattern of warm and cold gulf streams we will leave out of consideration here, because while it is true that the effect of this would be disastrous, it is completely unpredictable.) The rise in temperature would cause a global rise of the sea level, due to melting of the polar ice, among other things, but especially due to the expansion of the ocean water. In addition, the amounts of rainfall would shift in Western Europe: the winters would become wetter and the summers would have longer periods of drought.

More discharge

This means that the rivers must discharge more water in the winter than is the case now, while the difference in the level with respect to the North Sea would be reduced, slowing down the discharge. When discharge increases and stagnates as well, the risk of flooding increases. However, in the summer the risk of water shortage increases and thus the ground water cannot be raised as much. This has negative effects on nature in the form of drying out, on agriculture (drought damage) and in older inner cities (pile rotting). Moreover, the sea water will penetrate further inland when the ocean is higher and the discharge is slower, causing salinisation and creating a saline wedge up beyond a number of intake points for drinking water provision.

Near-disasters

In the past few years, we have had to deal with serious flooding in the Netherlands a few times, both due to very high discharge of the rivers and extremely high precipitation. The near-disasters which were created by this were related by many people with imminent climate change. In any case, these events caused two responses. On the one hand, work was begun energetically on the Big River Delta Plan, which reinforces river dikes and quays and has reasonably safeguarded the safety of property and goods. On the other hand, a discussion was started about the way we should actually deal with such developments over the long term.

Virtual certainty

The awareness has gradually grown that we cannot continue raising and reinforcing the dikes if the sea level rises on the one hand and, if on the other, the ground level in the west of the Netherlands still continues to drop. Ever higher dikes and bigger pumping stations offer a virtual certainty of very high communal costs; if something goes wrong in such a situation, the consequences would be that much more severe. Therefore, under the motto Room for the River, a better approach was sought for the problem in the past five years. The Room for the River Policy took effect in 1996.

Fourth Water Economy Memo

The government decision of the Fourth Water Economy Memo (NW4, 1999) also focused on the protection at high water for river discharges expected to continually increase: “The government opts for more room for the rivers. Where possible, unnatural obstacles are removed, parallel ditches are restored and the winter bed is lowered. Dike reinforcement becomes the final part in high-water protection. The government reinforces the coherence between water management, environmental planning and nature development. The long-term strategy for the big rivers is imbedded in the national environmental planning policy”, according to the NW4. “By opting for room for the river, opportunities for a number of activities will have to be sought for elsewhere in the river area. Room for the river will not be able to remain without consequences for the environmental planning in rural areas.” Meanwhile, regional directors of Rijkswaterstaat [Federal Water Authority] have carried out various partial studies on the possibilities for the Meuse, for the Rhine, for the lower river area and for the IJsselmeer area, in which this approach has a central position. However, the question meanwhile remains of how the relation between water management and environmental planning would be shaped.

Tielrooij Commission

In April of 1999 the minister of Transportation and Public Works and the Union of Water Authorities instituted a commission which would work with the question of what the consequences would be for the water management of the rise in sea level, climate change and drop in ground level. This commission, officially the 21st Century Water Management Commission, and informally usually named for its chairman as the Tielrooij Commission, published its recommendations in August 2000, with the motto “Give water its free course and the attention it deserves”. It appeared in the process that the commission was very aware of the tension between water management and environmental planning, and – fortunately – took up its task in a broad sense. In addition to safety, flooding and damage, it demands attention for a different approach to water management, room for water, more involvement by citizens and the government, better steering and direction in the water policy, and for cost and benefit of a different policy. The commission also focuses on the quality of water where this is at issue due to problems such as drying out and salinisation.

Recommendations

The Tielrooij Commission makes the following recommendations:

- The 21st century demands a different approach of the water policy than the 20th. We are already frequently up against floods and damage. Safety is not always guaranteed. The imminent climate change and more intensive use of space and ground will get worse in the long run. Politics and administration must make a fundamental decision. The water system is not in order now NOR for the future, quantitatively and qualitatively.

- No different water policy without support. Politician and citizen must be much better informed about threats and risks caused by water and must be more directly involved in a different approach to water policy. Only then will they not only consider water an enemy but also an ally.
- The 21st century water policy must be organised on the basis of three principles: retaining the water and temporarily store it; room for water; utilising chances for multiple-use of areas.
- The present system of water management has great potential for passing the buck, with all the problems that come along with it. The basic assumption for the new water management must be: no shifting of responsibilities in the water system itself, nor of administrative responsibilities and also not of the costs.
- The three-step strategy of “retaining, storing and only then discharging” must be used in all government plans as compulsory principle for determining priorities, and must be the object of administrative testing and administrative law testing.
- The already implemented policy of the federal government, the provinces and the water authorities for Room for the River, integral policy for water and room and for multiple use of areas must be continued and translated into action programs with concrete tasks being planned for each watershed. In the municipal policy, the opportunities must be taken advantage of to provide room for water and increase the environmental quality.
- The water test will be compulsory in making decisions on large-scale and/or drastic decisions on location. The quantitative and qualitative consequences for the water system are studied and compensation measures are taken wherever necessary. The water authorities are questioned about this.
- In PCB’s and environmental and destination plans, room is reserved for temporary water storage and primarily intended for “water management”. Purchases as well as private law agreements ensure that this room is available at the crucial moment.
- The water policy will be based on the watershed approach. International and regional watersheds are indicated and watershed programs are developed. Regional alliances and regional platforms support making decisions.
- A system of standards will be introduced for each regional watershed. The basic standards are established nationally, the province establishes the eventual standards for each watershed. The water authorities ensure water management in accordance with the system of standards.
- The existing safety standards for the big rivers and the coast are outdated. The risks have increased considerably. On the basis of the proposals already at hand, the present system of risk approximation are replaced by a risk approximation in which chance AND effect are compared.
- The present system of damage compensation by the federal government is replaced by an insurance system for damage due to rainfall and possibly also for damage due to flooding of temporary water storage systems. Damage due to flooding of primary dikes will be compensated by the federal government.
- The role of director by the co-ordinating minister of Transportation and Public Works on the international and national levels is reinforced by and based on a political choice of policy in a new Water Policy Memo. The co-ordination refers to the quantitative and qualitative water policy, including the effect passed on to different governments.
- The province is assigned the director role for the regional watersheds in the development and implementation of the watershed programs. It fulfils this role in co-operation with the other governments and social organisations.
- A different approach to the water policy means a different manner of government administration and calling in different steering possibilities. It also demands a drastic adaptation of the official organisation, especially for the federal and provincial governments.
- The additional costs of the proposed adaptations in the water policy are estimated at 500 million guilders per year. These costs are justified by their intrinsic necessity and the long-term benefits.

Consequences for environmental planning

It is clear that the recommendation of the Tielrooij Commission have considerable consequences for environmental planning. Chairman Tielrooij said about this at the presentation of the recommendation, that Vinex locations such as IJburg near Amsterdam, Waalsprong near Nijmegen and other large projects would perhaps not have been planned or perhaps planned differently in view of the findings by the commission.

Social support

In the fall of 2000 and the spring of 2001, the Tielrooij recommendations were the subject of a large number of study meetings and symposia, anticipating the implementation of the recommendations in the Fifth Environmental Planning Memo. In these, there turned out to be wide social support for the broad outlines of the recommendations. Everybody agrees that it all must be done differently. Also the "new trits" of the Commission: first retain the water, then store it, and only discharge if there is no other option (VBA) met with a great deal of appreciation.

Water quality given insufficient attention

However, there was also criticism. Due to the assignment by the 21st Century Water Management Commission, it was obvious that the recommendations would primarily focus on safety and risk aspects in case of extreme flooding. This caused the water quality and problems of water shortage to be given insufficient attention in the final report.

Water test

The proposed "water test" also provoked a lot of discussion. People generally agreed that such a test for big environmental planning projects must be instituted in the future. But the question is whether this must take precidence over all other matters, or must be a fixed component of existing environmental instruments, such as the Local plan or the Destination plan.

Position of the Cabinet

In the middle of December 2000, the cabinet position on the recommendations of the 21st Century Water Management Commission was presented and the House of Representatives gave its assessment half a year later.

The cabinet agrees with the Tielrooij Commission that there is need for a change in water management, so it appeared from the cabinet position, recorded in the WB21 Memo. And the House of Representatives fully stands behind this, as is clear from the memo consultation on June 25, 2001. Thus it seems that nothing will stand in the way of the desirable change and that is good. Nevertheless, there are still some catches that might impede an effective implementation of the Tielrooij chain of ideas. The most important questions still up in the air after the debate are related to direction and the water test.

Direction and water test

Water management is part of a matrix with the hierarchy the Federal government, province, water authority and municipality, and horizontally the various ministries: Transportation and Public Works; Housing, Spatial Development and the Environment; Agriculture, Nature Management and Fisheries; Economic Affairs; Finances. The government representative in charge is the assistant-minister of Transportation and Public Works. However, at the same time, starting at the end of 2000, the trajectory of the Fifth Environmental Planning Memo by the minister of Housing, Spatial Development and the Environment will take effect. And the recommendation of the Tielrooij Commission will also play a significant role in it. All factions agree with this: a water test must be created which can be the standard for assessing environmental development intervention. What shape this test will have to have and how it must be fit into the framework are still completely unclear, however. RIWA is, in any case, a proponent of a water test which can be use effectively. At the participation procedure for the 5th Environmental Planning Memo in 2001, RIWA even argued for expanding the water test with the drinking water theme. In any case, it is clear that water will be assigned an essential role in environmental planning. How the implementation of the proposed watershed approach is to continue is still the subject of extensive discussion and study, however. It may be true that the chosen policy connects well to the European Water Framework Directive in this, but its elaboration by the Ministries of Transportation and Public Works, of Agriculture, Nature Management and Fisheries and of Housing, Spatial Development and the Environment in particular will once more add the question of direction to the agenda.

The European Water Framework Directive, watershed and integration

At the end of June, 2000, the European Parliament passed the EU Water framework directive which gives direction to a new European water policy. The basic assumption of the new directive is the approach to watershed in which ground water and surface water are considered in respect to each other, both qualitatively and quantitatively. Integrated management of watershed, even across political and administrative borders, will take place by means of co-ordinated programs of measures.

Reintroduction of brackish water zone leads to changes in the bank vegetation such as this reed (Photo: Jan v.d. Broeke)

Quality status

The objective of the directive is to reach quality 'status' for all water within the European Union in fifteen years. For surface water, this means a rich, balanced and durable ecosystem and respect for the environmental standards for pollution. Quality ground water means that backing out of and changes to the addition will not cause any damage in the long term to the durable nature of the ground water and that environmental standards are being observed. Measures are taken in the member states in order to achieve a high degree of protection for the water environment on the one hand, while on the other the availability of water for human consumption and for economic purposes is ascertained. The directive indicates ways for a combined approach to emissions and discharge. The framework directive also introduces a 'water price', the social and environmental value of water expressed in money.

Five steps

The directive uses five steps in its elaboration, which have a six-year cycle, at maximum, for each watershed. First, the characteristics of the area are mapped out. Next, the environmental stress factors are identified. The third step is the design and implementation of the measures which are necessary to meet the objectives of quality 'status'. The fourth is following the development by monitoring. And finally the measures are reviewed, if necessary, on the basis of monitoring.

The framework directive leaves room for special protected areas, for example for swimming water or for drinking water extraction. Furthermore, the member states can set additional requirements on a national level to water management in special areas.

Break-through

European commissioner general Margot Wallström appeared to be very happy that the commission's proposal has now been agreed upon by the European parliament after three years of negotiations. She called it an important break-through for the European water policy, which will not only soon have an effect on the water quality, but will also safeguard it for future generations.

Watersheds

Management plans for watersheds form the core of the Framework Directive. That is very unambiguous in itself, but it does require special attention for the direction. International co-operation will be necessary for the big watersheds of the Rhine, Meuse, Scheldt and Eems. The 21st Century Water Management Commission has an important role for the partial watersheds in mind. This means that at the Federal level the governments must participate in the international dialog, as is already happening, but that this dialog will entail more obligations in the future and it must be possible to test it against the directive. On the other hand, the Federal government will have to indicate the framework to the provinces within which the partial watersheds will be developed and managed.

Rhine watershed

After the Water Framework Directive took effect on December 22, 2000, its effect became noticeable during the 13th Rhine Conference of Ministers which was held on January 29, 2001. Not only the treaty nations of the International Rhine Commission were invited (Germany, France, Luxembourg, the Netherlands and Switzerland), but also the remaining countries in the Rhine watershed, being Liechtenstein, Austria and Walloon. In a separately published second communication (below in this annual report) the first steps are made for complete management of the Rhine watershed.

Second World Water Forum and minister conference

From vision to action

The world of water fell under the spell of the Second World Water Forum from March 17 to 22. The conference took place in the Hague. Forum chairman Prince Willem-Alexander manifested himself as a water expert before an international audience for the first time. His actions gained respect from everywhere. Following the Forum a minister conference was held on the results and recommendations. 120 countries were represented at this conference. As far as the number of participants and publicity, the WWF was certainly a big success.

More than 5700 participants from all over the world came to the Hague to let their voices be heard. There were also some very critical voices. The diversity of backgrounds of the participants was striking: from water experts and official government representatives to delegates from social organisations, youth and indigenous peoples. This mixture made the Forum a very lively event.

At the presentation of the Rhine Vision on the first Forum day, IAWR made it clear what importance the water companies attach to a clean Rhine, forming the source of drinking water for about 20 million people. Parallel to the forum, a trade fair was organised with the name World Water Fair, where the RIWA provided information about the current situation of the Rhine, Meuse and Scheldt by means of video images and publications.

According to the Prince of Orange "Our message is that water is a crucial subject which needs urgent attention, conveyed loud and clear". This could be attributed in part to the media attention. More than six hundred journalists attended the Forum. Water finally has a solid position on the global agenda.

World Water Vision

Millions of people still live in harrowing hygienic conditions and have no access to water. Many countries are burdened by the constant threat of extreme drought or else floods and by the daily deterioration of the environment. Half of all wetlands disappeared in the past century. Half of all rivers are poisoned and some no longer even reach the ocean.

A worldwide effort was made for almost two years to formulate a World Water Vision which states how this situation can be terminated. 15 thousand people were involve in this. Discussing and passing the concept of this vision, along with an action Framework was an important objective of the Forum. The forum chairman considered the meeting as the starting point of a 'water movement'.

Privatising water sources

An often recurring and vehemently discussed topic was privatising water sources. Water is no longer an exclusive matter of governments and public companies, but it is not very clear which model is best for replacing this state monopoly. In any case, this will not be a private-sector monopoly. According to the Vision, water sources are a common inheritance. "When we establish the right to water, we are talking about user rights and not property rights." In his report to the minister conference, the Forum chairman mentioned the consumers' rights to access to water sources and their rights to actively participate in the management of these sources as two important topics. A vast majority of the participants in the Forum urged the ministers to explicitly recognise these rights. For many people these are conditions for escaping poverty. That does not mean that water provision must be free of charge. The Vision proposes charging the prices of water provision in their entirety, but granting the poor people sufficient subsidy for this. Not all participants could agree to this.

During the panel discussion on the role of business and industry (including agriculture) it became clear that investments from the private sector are becoming more important for bridging the gap between demand and supply of water. But the sector will only invest time and money in new technology and product innovation if this is compensated by a good price for water as a valuable resource. It was recognised that industry can still do a lot by reducing its own water consumption and the pollution associated with it. The business sector declared itself willing to enter into co-operative relations with others to share knowledge and technology and to stimulate the awareness of the importance of water for the public at large.

Dams

Building dams is a controversial topic. The opening ceremony was interrupted by an action group which protested vehemently against this. A minister from Mozambique, on the other hand, asked for help building dams. His country was recently ravaged by serious floods.

No safe drinking water in Russia

Every Forum day some part of the world took centre stage.

The first day this was Europe with sessions on the Rhine watershed, the countries surrounding the Mediterranean, Central and Eastern Europe, and Russia. Since the collapse of the Soviet Union, the water situation in Russia has deteriorated drastically. There is sufficient water itself, but half the population does not have access to safe drinking water. About a quarter of the drinking water is lost due to the deplorable condition of the water network. Experts are afraid that the situation first must deteriorate further before steps are taken to correct the situation.

Unreliable supply big problem

The second day featured Africa and the Middle East. Fourteen African countries are facing serious water shortages. This number is expected to increase considerably. Better water management and the development of water sources are of great importance for the socio-economic growth and the improvement of the environment.

During a session on West Africa, the participants observed that the unreliability of the water supply is a bigger problem than the price of it. "Users generally have no objection paying for water if they can, for they *know how* important water is," reported the chairman to the conference of ministers.

Lack of money

The third day was Asia day. This continent also has serious problems. 300 million people in South Asia have no safe drinking water and 920 million people have no sanitary provisions. Clean water is scarcely available in the cities. However, the most important problem is not the water itself, but the lack of money for water provisions. A great deal more money must be invested in water projects.

One outstanding guest speaker on the day of the Far East, Australia and the Pacific Ocean was Michael Gorbachov. He was part of a panel on the subject “Water for peace in the Middle East”. The session was organised by the International Green Cross. “When God created the rives, he did not know we would create nations with these rivers as their borders. There are no national solutions to our water problems. They must be approached internationally,” according to the former Soviet President. He said he expects the water shortage in the Middle East to lead to war if it is not alleviated within ten years.

A few days earlier, a special meeting was dedicated to the subject “Water and conflicts”. The conclusion from this session was, surprisingly enough, that it is not probable that any wars will be started over water in this century.

Need for educational programs

On the fifth day, North and South America took centre stage. South America is a continent with a great diversity of ecosystems. Pollution and tourism were two topics on the agenda for this day. Environmental problems are on the increase due to urbanisation. In many countries the intense use of pesticides poses a serious problem. Tourism is an indirect cause of water pollution due to building of hotels and roads. Protection of the ground water supply barely exists.

There is a great need for programs to teach people the importance of hygiene and dealing with their environment carefully. For that matter, this is not only true for South America.

At the end of the conference, host country the Netherlands promised to double its donations to activities in the water sector in developing countries from 40 million dollars to 80 million dollars over a four-year period. Furthermore, 8 million dollars will be made available for export of know-how.

NGOs said in a statement that they had been insufficiently involved in the preparation process and did not agree with the contents of the Vision and the Framework for Action. They urged the ministers to reject the reports. The Forum chairman admitted that mistakes had been made in preparing the Forum, but that these could be improved upon in the follow-up phases. The Third World Water Forum will be held in Japan in 2003.

The Rhine in the 21st century: a durable, integrally managed water system

In the course of the process of arriving at a World Water Vision on the occasion of the Second World Water Forum, a great number of regional and thematic views were developed. The Netherlands has taken the initiative for creating an vision for the Rhine watershed. In a brief period, a few workshops and brain storm sessions were organised and numerous experts were interviewed in the Rhine bank states. The results are summarised in “Rhine Vision” which was presented on the European day during the World Water Forum.

Discussion document

The document contains facts, lessons learned, views and wishes of people who feel involved in the fate of “Father Rhine”. It has the status of a discussion document. The objective of arriving as quickly as possible in the 21st century at a durable, integrally managed water system is shared by all. But opinions vary on how to interpret the terms “durable” and “integrally” and the manner in which the objective can best be reached.

The Rhine vision shows what successes were achieved in the past, but also what mistakes were made. The document is intended not only to make the reader reflect on the near future, but also on the long-term consequences of the current policy for the Rhine and other rivers. With this, the authors especially bore in mind the participants in the World Water Forum rather than the inhabitants of the watershed itself. Thus, the document offers a great deal of basic information for people to whom the Rhine is a relatively unknown river.

Future image

The vision describes a future image of the use and development of the river and its watershed on the basis of wishes and preferences of all parties involved. They share their vision on a watershed

- in which use and management are invariably focused on the possibilities and limitations of the water system;
- in which all parties involved pursue durable development of water-dependent ecosystems;
- in which each party with an interest is aware of the possibilities, restrictions of and threats to the water system;
- in which each party with an interest is given the opportunity to participate in making decisions on use and management of water and
- in which such decisions are made on the basis of solidarity and mutual understanding and by means of consultation and negotiation, taking into account the present and future interests in all parts of the watershed,
- so that a proper balance is reached allowing the water of the Rhine and its tributaries to meet the requirements of all functions and use.

These are fairly abstract formulations. The text did have to remain vague or else an agreement would not have been reached, as the authors honestly confess.

Scenarios

In order make the vision more concrete anyway, three scenarios have been drawn up. They are stories about a possible future of the watershed in 2025.

The first scenario describes the situation that is created if the present policy is continued. A real water crisis will not be created in the watershed, but the quality of the living environment will deteriorate and the water system will become more vulnerable.

The scenario of “economy, technology and the private sector” puts its faith in the market effect, the involvement of the private sector and especially in technological solutions and actions on the national, local and watershed levels. It will lead to a more durable water economy but could end up in less solidarity and more conflict between the countries upstream and downstream and between rich and poor.

The third scenario is that of the “values and lifestyles”. Core concepts in this scenario are revision of values, reinforcement of international co-operation, education, international rules and procedures, increasing solidarity and changes in lifestyles and behaviour. This scenario ensures a more durable water system in a world that now looks utopian, but which could eventually become reality (albeit maybe only after a disaster, for example a serious flood, has made people aware of the need for change).

Integral and international approach necessary

In order to be able to make plans for the future, it is necessary to take the lessons from the past to heart. The document sums up the highlights of the past 200 years of history of the Rhine. The most important problems in the watershed involve industrialisation, cutting off curves and canalising the river, building quays and dams, fast growth of the population in the bank states, disappearance of the water meadows, water pollution, destruction of the habitat, etc. Add to this the threat of climate change.

Thus it is clear that in the meantime the river needs more room. Certainly now that heavier rain showers will fall ever more often as a result of the change in climate. Sooner than later all that water ends up in a river that has itself already been straight-jacketed. The Rhine vision: “We must create room for the river and consider it as a basic principle of environmental planning. Society is only prepared to relinquish that room to the water if the public at large is aware of the necessity for this. This requires information, knowledge and understanding.”

The most important lesson from the past is the necessity for co-operation on the basis of mutual solidarity and with consideration of each others’ interests. Too often ad hoc measures were taken on a small scale in the past, for example after a flood, which did (temporarily) provide relief locally, but which caused new problems elsewhere in the watershed. That is why an integral and international approach is necessary, in which all parties with interest are involved. The work of organisations such as the fifty-year-old International Rhine Commission (IKSR) must be pursued vigorously. In 1999, the Rhine ministers agreed upon a new Treaty for the protection of the Rhine, including water quality and quantity and ecological aspects. The IKSR reconvened on January 29, 2001 to add further concrete measures to the Treaty, like the program “Rhine 2020” for durable development of the Rhine.

Construction of housing units on the outside of the dike along the IJsselmeer (Photo: RWS-Directorate IJsselmeer area)

The future of the IJsselmeer area

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The IJssel area is formed by the IJsselmeer, the Markermeer and the Randmeren. With a surface area of more than 2000 km^2, it is one of the larger fresh water basins in Europe. For a considerable part of the Netherlands, the area forms an important fresh water basin. The water supply is used in the peat areas of North Holland and Utrecht for maintaining the ground water level in order to counteract settling of the peat soil. During the summer months, the IJsselmeer water in the northern provinces is used for agriculture and for flushing the temporary water storage system in order to prevent an excess chloride and phosphate concentration and counteract excessive algae growth. The lakes also provide processing, cooling and flushing water for many companies in the area. In addition to that, the IJsselmeer area is important for inland navigation, fisheries (albeit to a decreasing extent), watersport, mining and as a bird sanctuary.

Drinking water

The drinking water provision in a large part of North Holland depends on the IJsselmeer. At Andijk, surface water is taken in which is purified into drinking water for 1.5 million residents. The water in the Randmeren [Marginal Lakes] is, indirectly, also of importance to the drinking water provision in part of the surrounding area. The water quality in the IJsselmeer area is usually of good quality, sometimes with a local increase in phosphate, chloride, nitrogen, pH or pesticide concentrations or excessive algae growth.

Water supply

The water in the area originates 70% in the IJssel and since this is fed by the Rhine, the Rhine water determines the greater part of the quality of the IJsselmeer water. Furthermore, the IJsselmeer is fed by the Overijsselse Vecht, the Veluwse streams, the Eem (Utrecht) and it serves for discharge of the adjacent polders and a part of the Northern Netherlands and Germany.

Distribution of the Rhine water at different debits

Supply at Lobith in m^3/s	IJssel discharge in m^3/s	Lek discharge in m^3/s	Waal discharge in m^3/s
less than 1300	less than 285	25	990
between 1300 and 2400	285	variable	between 990 and approx. 1700
more than 2400	1/9th part	2/9th part	6/9th part

Under normal conditions, the IJssel discharges a fixed amount of 285 m^3/s of the Rhine water that enters the country at Lobith. When the debit exceeds 2400 m^3/sec at Lobith, the dams in the Lek are completely open and all the Rhine branches, including the IJssel, fill up.

Water discharge

Superfluous IJsselmeer water is discharged into the Waddenzee via the spillways in the Afsluitdike at Den Oever and Kornwederzand and via the spillways at Enkhuizen and Lelystad into the Markermeer, which has been separated from the IJsselmeer by the Houtrib dike since 1975. The tide and weather are important for discharge into the Waddenzee, since the water is sluiced by gravity: the locks open up at low tide and remain closed at high tide or during bad weather. In case of hard wind from the north, the water of the Waddenzee is pushed against the Afsluit dike and sluicing cannot take place, even at low water. In the past the downstream basin would first expand naturally in horizontal direction in such circumstances. This is no longer possible in the present IJsselmeer, for the embankments have been established by sturdy dikes all around. In addition to that, the original basin has been reduced in size over the years. Therefore, a peak in water discharge will lead to a rise in the water level in the lake more quickly and more forcefully.

The straight lines of an IJsselmeer polder (Photo: Geometry Department)

Breaking the tendency in use of space

The tendency of utilising the space of the original Zuiderzee for all kinds of useful purposes was halted by the water itself in the last decade of the previous century. Three successive periods of extreme high water, two of which were caused by high peaks in discharge of the Rhine, led to a wave of reflections on water management in the Wet Heart (Centre) (the IJsselmeer area including the North Sea canal and the Amsterdam-Rhine canal).

Characteristic for those reflections were two policy exploration projects which were realised in the course of 2000 and which are, each one in their own area) important to the future of the IJsselmeer area.

- In the project “Water economy in the Wet Heart” (WIN), the consequences of climate change and ground settlement for water management were explored. In this project, which was initiated in 1998, safety is central and thus it forms one of the cornerstones of the 21st Century Water Management Commission Recommendation.
- The intention of the project “Integral IJsselmeer area vision until 2030” is to indicate, with inclusion of the many divergent interests in the area, how the future developments must be dealt with and to map the consequences of certain choices. In the fall of 2000, the Provisional Vision was distributed as a discussion document and also included in the Fifth Environmental Planning Memorandum.

Integral Vision on the IJsselmeer area until 2030

The “Provisional Integral Vision on the IJsselmeer area”, which was published in the fall of 2000, focused on the choice of three core values:

- horizon (representing openness, quiet, room and absence of light pollution);
- natural wealth (including the water, wind, the water ecosystem and the natural substrate);
- culture (the still remaining cultural historical components from the time of the Zuiderzee as well as the history of making the polders. Fisheries are also included in the former category, the dikes in the latter).

These core values function as a type of compass which must be constantly available in all initiatives, developments and policy selections in order to approach the course established in the vision as closely as possible. In addition to the core values, a few pre-conditions also play a role. The most important one is the guarantee that the politically weighed and legally established safety level be maintained. The second pre-condition is that the IJsselmeer remain a sweet water lake according to the requirements which drinking water providers and agriculture set for it.

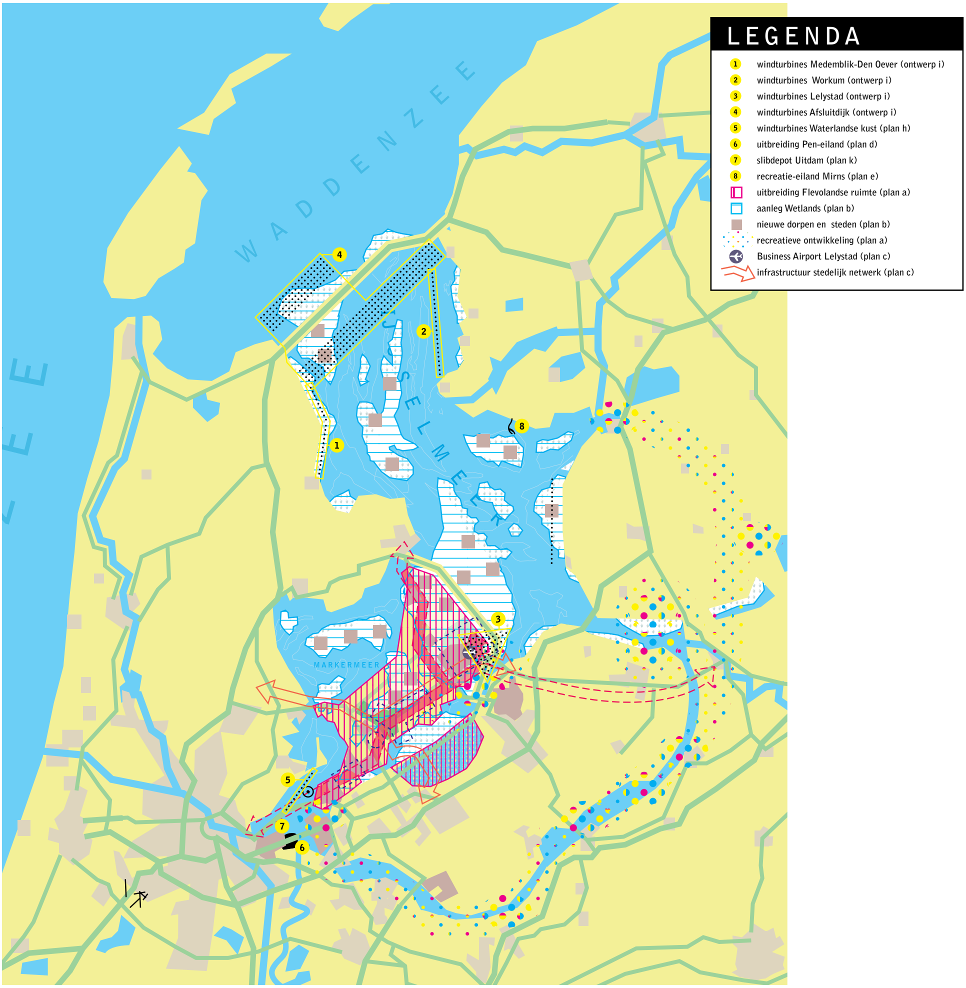
Contrary interest

Since the integral vision is to a large degree the result of arguments, points of view, powers and forces of the different players, these are broadly expanded upon in the document: the core tasks of the water manager, the environmental and economic ambitions of the IJsselmeer cities, the dreams of the nature managers, the requirements of agriculture, the conditions of the drinking water providers, the interests of the recreational sector, the worries of the cultural historians and the problems of the IJsselmeer fishermen.

Division into zones as a solution

When we take a closer look it turns out that the people who drew up the plan are definitely aiming for a different course. They do not want everything everywhere, but a division into zones according to the gradient from open and quiet to dynamic and intensive. In other words: in the south and the middle (zones I and II), where quiet has already disappeared, expansion of existing activities is permitted and new initiatives are welcome. In the northern part (zone III), where the area is still open and relatively quiet, new activities and developments are only possible if these support the core quali-

If all plans were implemented, little would remain of the IJsselmeer (Drawing: Dik Klut)



ties – openness, landscape, nature and maintaining (drinking) water provision. Moreover, the vision already indicates in global terms which concrete changes will be necessary in the present policy:

- realising water storage inside the dikes and making changes in the level schedule in the IJsselmeer;
- realising shallow wetlands outside the dikes in order to complete the IJsselmeer area "as an ecological mainport";
- principle NO to construction outside the dikes, with a possible escape clause under strict conditions;
- stimulation of recreation in the south and the middle;
- preventing crowding by wind mills and taking bird migration routes into account.

The definitive 2030 IJsselmeer area Integral Vision was drawn up in the course of 2001 and signed by the ministers of Agriculture, Nature Management

A calmer and more balanced vision on the IJsselmeer (Drawing: Dik Klut)

and Fisheries; Economic Affairs; Housing, Spatial Planning and the Environment; and Transportation and Public Works in the fall. It will serve as the cornerstone for the future Second Green Areas Structure Schedule.

Water economy in the Wet Heart

The IJsselmeer, Markermeer, the Randmeren, the Amsterdam-Rhine canal and the North Sea canal form the Wet Heart (WIN) of the Netherlands. The "Wet Heart" (WIN) project was already set up by the Federal Water Authority a few years ago in order to explore the consequences of climate change, rise of the sea level and settling of the ground and to make suggestions for the measures to be taken. For safety must also be guaranteed in the long run, as well as durable use.

Climate change effects

With respect to the climate, changes are expected before 2100 which will play a role in the Wet Heart:

- A rise in temperature of 1 to 4 °C, increase in precipitation by 3 to 12%, and a relative rise in the sea level of 20 to 110 cm.
- Increase in Rhine water discharge in the winter and decrease in the summer.
- Increase in extreme levels of IJsselmeer and Markermeer on the same order as the rise in sea level, especially in the winter, while the lake level in the summer may even drop.
- More frequent and higher water levels in the North Sea canal and the Amsterdam-Rhine canal, because it will be more difficult to sluice water by gravity at IJmuiden. Expansion of the pumping station capacity is foreseen.
- An increase in saltwater seepage by 10% in the areas surrounding the IJsselmeer (due to a rise in the sea level and drop in the ground level).
- Possible shortage of water in the summer due to limited water supply.

Implementation

The WIN project was implemented in four phases, and water authorities, municipalities, provinces and special interest organisations were consulted. A WIN memorandum of conclusion was drawn up in the conclusion phase. A concept version was submitted to deputies, bank maintenance officials, mayors and aldermen in the planning area and consequently adjusted. On May 24, 2000, the assistant minister of Transportation and Public Works presented the Memorandum of Conclusion of the 21st Century Water Management Commission.

Three strategies

Three of the four possible directions for solving the future water economy problems have been elaborated into serious strategies. A number of basic assumptions had already been established in advance. Pre-conditions were the safeguarding of safety and maintenance of the Afsluit and Houtrib dikes. Neither was it permitted to change anything on the present discharge distribution of the Rhine branches nor on the pursuit of flexible water systems, while an already-planned 100 m^3/s expansion of the pumping station capacity in the canal area was already certain.

The following strategies were explored:

1. In the winter the Wet Heart is given a great deal more water to process at irregular times. A first possibility would be to discharge the water directly at accelerated rate from the Wet Heart while maintaining the present levels, so that the dikes do not have to be reinforced. Additional sluicing capacity is necessary for this and in the long run also pumping station capacity on the Afsluit dike.
2. A second possibility is storing the water “vertically” in the lakes by allowing the lake levels to rise slowly, keeping pace with the rise in sea level. That means that the dikes must be reinforced. Additional pumping station capacity is necessary for discharge of water from the regions to the IJsselmeer. The advantages of this option are that a more natural level management is possible and that the fresh water supply is increased.
3. The third possibility is storing the water “horizontally” in the lakes by designating flood areas in the surroundings of the IJsselmeer area, which can absorb excess water every few years. The lake levels will rise somewhat, making reinforcing the dikes necessary. The advantages here are again a more natural level gradient and a bigger fresh water supply.

A fourth possibility, reducing the water flow into the Wet Heart, was launched as a mind experiment, but was not included in the further deliberations.

A number of strategies were linked to these solution directions. This exploration led to the fact that a pumping station on the Afsluit dike was taken off the list because of the artificiality, vulnerability and high social costs. Horizontal storage has also been dropped as an option. A great deal of storage area would be necessary and that is not considered financially and technically feasible. Moreover, the effect of such storage polders in the Wet Heart is doubtful.

Preferred strategy

The preferred strategy can be described as "growing along with the sea", with expansion of the sluicing capacity, further dike reinforcement and a rise in lake water level in the IJsselmeer area as the consequences. A step-wise plan has been drawn up for the short term until 2025, consisting of the following "no-regrets measures":

1) Establishing pre-conditions for building outside the dikes (2001).
2) Exploring season-dependent level management in the IJsselmeer area (starting in 2001).
3) Exploring the future of the IJssel and Vecht deltas (starting 2001).
4) Expanding pumping station capacity of the canal area (plan study begun).
5) Expansion sluicing capacity of the Afsluit dike (plan study begun).
6) Initiating a season-dependent level management.

Season-dependent level management

What exactly are the results of the preferred strategy "growing along with the sea" for water management? Level management will be season-dependent. The Memorandum of Conclusion gives the following definition of this:

"Level management where target levels are used which vary throughout the year according to a development which is partly based on the natural discharge of a river. The target levels and margins to be used are set in such a manner, however, that there are positive effects on nature and water provisions (high spring level, dropping in the summer), that there are no effects on decisive situations for safety (low levels in the storm season) and that there is a neutral to positive effect for other types of use."

Season-dependent level management must not be confused with a more natural level development, in which the water levels follow the natural discharge of – in the case of the Wet Heart – the IJssel.

The average summer and winter levels will rise along with the sea level in the future. This means that the sluicing capacity of the Afsluit dike will eventually have to be expanded.

Independently from the WIN project it was decided quite some time ago to expand the sluicing capacity of the Afsluit dike in 2003. This "no-regrets measure" will also be sufficient in the long run. The WIN Memorandum of Conclusion warns that this does not mean that measures for water storage and water conservation in the surrounding areas can therefore be omitted. They will remain necessary, among other reasons to combat a drop in ground level and salinisation. Fresh water provision for the regions will remain safeguarded by the high spring level. The water quality remains the same. However, a new round of dike reinforcement will be necessary in the period 2025 to 2050.

The water discharge from the surrounding regions into the Wet Heart will be more difficult due to the new level management. The pumping station capacity will have to be expanded considerably from the middle of this century.

This may be done in correspondence with measures to combat salinisation, a drop in the ground level and drying up.

The IJssel and Vecht deltas are the transition areas between these rivers and the Wet Heart. The exploratory “Room for Rhine branches” study shows that a raised decisive discharge of the Rhine up to 16,000 m^3/s can be safely processed in a brief period with a few river-broadening measures, without changing the distribution of water among the river branches. But we don’t know what will happen when an even larger amount is discharged as a result of climate changes. What should happen with all that water in the IJssel, even more so since the results of the rising sea level will be noticeable on that side of the IJsselmeer by that time? A study of the future water-economic situation in the IJssel and Vecht deltas, as a follow-up to the WIN study, is urgently required.

Additional Sluicing capacity and Ecological coherence along the Afsluit dike – [ES]2 – Afsluit dike

A central component of the preferred strategy is season-dependent level management. It is therefore important that the possibilities of a season-dependent level management in the IJsselmeer area be further explored. That is, different variations are possible, for example as far as the date of implementation and level of the high spring level are concerned. And in the winter, anticipatory sluicing may make it easier to manage the level. The scope of the additional sluicing capacity on the Afsluit dike depends on the eventual choices.

At the moment 15 (12-metre) spillways at den Oever and 10 spillways at Kornwederzand sluice water by gravity for 4 hours at low tide. The difference between the IJsselmeer and the seawater at low tide is 50 cm, on average. It

The locks in the Afsluit dike sluice by gravity (Photo: RWS-Directorate IJsselmeer area)

is expected that this difference will be reduced to 25 cm by 2050. Since the low tide level at the seaside at Den Oever seems to rise and the IJsselmeer level at Kornwederzand is pushed more often (due to the prevailing western to south-western wind), the latter location appears to be most appropriate for the expansion (and possible doubling) of the sluicing capacity because of the bigger difference between the two levels.

Flooding and sluicing capacity

Implementing the expansion in such a way that more ecological coherence is also created between the Waddenzee and the Ijsselmeer is also called for. This is a very difficult and complicated task to assume. After all: the direct stimulus for increasing the sluicing capacity at the Afsluit dike has nothing to do with ecological coherence, but was inspired by failing of the temporary water storage system function of the IJsselmeer at the end of 1998. This resulted in flooding in parts of the IJsselmeer polders, Drenthe and Overijssel, with the consequence that the discussion about the approach of the flood was accelerated. In the wake of this, the Federal Water Authority started a plan study with an MER procedure and design studies for the new spillways and an eventual brackish water zone. The intention is to make a decision in 2003 to begin construction in 2004 and put the installation into operation in 2008.

Plan process and participants

So far, participants involved in the consultation rounds were all IJsselmeer municipalities, water authorities, provinces, various sections of the Federal Water Authority and of the Ministries of Agriculture, Nature Management and Fisheries and Defence, the sector organisations for fisheries, navigation and recreation, social organisations in the area of nature and the environment and a number of consultation agencies and RIWA.

Eight possible sluicing locations

The discussion documents prepared by the Federal Water Authority (RWS) present eight possible sluicing locations at different points in the Afsluit dike. The drawings of a possible estuary area involve both the fresh water and salt water sides. The remarkable fact is that none of the designs include the actual spillway as part of the estuary area to be created. They do lie close to each other, but are separated by dams. This has to do with the considerable irregularity in the sluicing pattern with respect to the modest scope of the intended brackish water zone (10 to 20 km^2). In wet periods with maximum water discharge, the brackish zone could become entirely filled with sweet water. Sudden drastic changes in salinity also lead to stress on living organisms and thus are in conflict with the positive intentions by means of gradual change.

Point of view of the drinking water providers

The drinking water companies have a role different from other participants in the discussion on fresh water. By themselves, they have no collective objections or objections dictated by their organisations to estuary recovery projects, but they do have one solid pre-condition: there may be no salt effect in the surface water in the areas where this water is taken in for the preparation of drinking water. This single requirement is so rigid because of the quality requirements which society sets for its drinking water. There will be no compromises in this. If this requirement can be met over the long term, those taking the initiative for estuary recovery projects will find drinking water providers on their side.

Ambitions curtailed

In the summer of 2001 the evaluation process for [ES]2 had proceeded to the point that the Federal Water Authority began to prepare the initial MER memorandum, but only for the “means of sluicing”. The research area to be included in the MER for this purpose is situated between Kornwederzand and Breezanddijk, with a provisional preference for the existing bend in the Afsluit dike west of Kornwederzand. Until that time, the rather schematically and numerically organised evaluation process mainly focused on the existing conflicts of interest surrounding the intended recovery of a fresh-salt water gradient. Fishermen, bargemen, nature and environmental organisations and various authorities all recognise that ecological values score high, but that this leads to divergent points of view in combination with their own sector interests. The difference in choices is demonstrated most clearly between the social organisations in the area of nature, agriculture and recreation on the one hand and the (Netherlands) Ministry of Agriculture, Nature Management and Fisheries on the other. The Federal Water Authority encountered a great deal of divisiveness and wrote a letter to all parties involved on July 17, 2001, stating that the brackish water zone could only be considered if it appears that putting the new means of water sluicing into operation would necessitate compensating or mitigating measures. Should this be the case, it must first be investigated, according to the letter, whether a brackish water zone is

Transition from salt to fresh (and vice versa) may lead to stress, making fish sick (Photo: RIKZ, Haren)

indeed the most appropriate means of compensation. This result was not entirely unexpected:

1. The first order to the Federal Water Authority was to create additional sluicing capacity.
2. All parties involved in the synchronisation phase have accepted the rock-solid preconditions that safe navigation and provision of fresh water for agriculture and drinking water may not be jeopardised in any way. The latter is an especially sensitive point, because the availability of sufficient fresh water in the IJsselmeer basin will become more uncertain in the future as a result of the rising sea level and stronger effects of the seasons on the discharge of the big rivers.
3. The Water Authority's water-economy order was not added to by the other parties involved, especially the Ministry of Agriculture, Nature Management and Fisheries, by one single broadly-supported vision on incorporating a brackish water zone.

Estuary gradients

Yet, focus on recovery of estuary gradients is gaining. Initially, the leading motives were only of ecological nature. After introduction of integral water management, the shared responsibility of maintenance and repair of natural values increasingly became a concern of water managers.

It was easy for them to combine this with new insights in the interest of flexible water systems, banks and the coastal zone. This process was given an additional impetus by the fact that people became aware of the necessity of more room for water.

Work conference on estuary recovery

However, during every search for opportunities of recovery projects, how much resistance and how many problems exist also come to light. The artificiality of our country with its strict infrastructure of roads, waterways and primary dikes is nearly irreversible within the regular horizon of time. Space is very scarce and almost always fulfils several functions. This is also true for water. Estuary recovery can be realised in the entire coastal area on a modest scale at locations which would be unimportant or of marginal importance to other user functions. In order to make larger-scale projects possible, the interest in and the insight into the why and how must penetrate further in broad layers of administration and management by making all existing knowledge and experience accessible. Consequently the theme must also be communicated in an inspiring way in broad circles. Because of that, RIKZ and RIZA have taken the initiative to set up a platform for bundling and exchanging knowledge about and experience with estuary recovery projects. This platform will be presented with a work conference at the end of 2001.

The River Scheldt

Introduction

Before you lies the first annual RIWA report on the Scheldt. In earlier RIWA annual reports on the Meuse announcements about the Scheldt were only published occasionally. After the international treaties for the Meuse and the Scheldt were signed in Charleville-Mézières on April 26, 1994, both treaties were printed in their entirety in the 1994 annual Meuse report and a brief item was also devoted to the signing. In reference to the first Scheldt Conference of Ministers on December 10, 1998, the “Declaration of Middelburg” was printed in the 1998 annual Meuse report and a brief chapter was devoted to the International Scheldt Commission inaugurated that year.

With the membership of the Vlaamse Maatschappij voor Watervoorziening [Flemish Water Provision Company] (VMW) at end of 1999, the decision was made to also include the Scheldt in the annual reports. The VMW extracts some of its production water from the Bossuit-Kortrijk canal, which is connected to the Scheldt. The expectation is that a larger portion of the drinking water in the Flemish Province will be extracted from surface water in the future. In this process, the role of the Scheldt can become more important as the Scheldt water becomes cleaner.

Because the Scheldt watershed is written about for the first time in this publication, it is only appropriate that a first general acquaintance with the river be made. The reader will notice how much the image of the river can change with how one looks at it. For example, the chemical analyst who assesses the water quality of the Scheldt will be surprised when an ecologist contends that the river has qualities one no longer finds in large parts of Western Europe!

The Scheldt is in many aspects an unusual river with many functions for social use and nature. The quality of the Scheldt water appears to be an important factor for most of these functions. Partially in view of the part of the watershed where most of the application functions are concentrated and where the effects on the water quality are the most acute, the central point of the description of the Scheldt concerns Ghent to the mouth of the river.

Scheldt watershed downstream from Ghent, where the ocean already makes its effect tangible

(Figure: Scheldt Information Centre/RIKZ)

The Scheldt characterised

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Exceptional river

Traditionally the description of a river begins at the source. The Scheldt presents every reason to deviate from that. The mouth of the Scheldt is in fact much more interesting. Twice a day, the North Sea chases its tide in and out. This has become a unique phenomenon in the low lands, because everywhere else the river mouths and their branches entering the ocean have been closed off or made closeable with impressive constructions varying from dikes and dams to spillway locks and storm flood barriers. When the dam in the Eems is finished, the Scheldt estuary will be the only nearly natural river mouth where the dynamics of tides and river discharge rule. The North Sea and the Scheldt determine where they meet and how the salt gradient changes. The Scheldt is an exceptional river especially due to the presence of an extensive brackish transition zone.

Lifeline of the Belgian economy

At the same time, the mouth of the Scheldt is the gate connecting the Antwerp seaport and the rest of the world. This makes the Scheldt estuary one of the most vital lifelines of the Belgian economy. Port and industry interests have a big influence on the river. In the first place this is a result of the Belgian requirement that the Scheldt channel must always be navigable for ever larger vessels. This has led to frequent intervention in the river bed. In addition to that, the industrial expansion has had an enormous effect on the quality of the Scheldt water. Now that there is an international effort being made to improve the quality of the water following the example of the Rhine and Meuse, the expectation may be expressed that the uniqueness of the Scheldt will just become more important.

From source to the mouth

With its length of 350 kilometres, the Scheldt is one of the shortest rivers in Europe. The source is found in the hills north of Saint Quentin. This northern French city lies about 125 kilometres from the ocean. The initially fresh, young stream ‘Escaut’ covers a trajectory of nearly three times that distance before it flows into the ocean. The hills of the Artesién ridge force the river to flow north and not negotiate the shortest distance, westward, to sea level, like the Somme, a river flowing very nearby. The brook is insignificant during the first fifteen kilometres, but at Cambray it is already navigable for vessels up to 1350 tonnes. Even before it reaches the French-Belgian border and has run a quarter of its distance, many brooks and streams have joined the Escaut. At Tournai (Doornik), the first city in Wallonia of any size, it can be considered a river of reasonable dimensions.

At Ghent, where the last locks are located, the Scheldt curiously makes a perpendicular turn eastward. It maintains its course away from the ocean for more than thirty kilometres, setting course to the north again at Ouden-Briel. Only past Antwerp, after passing the Belgian-Dutch border, does the river flow westward to the ocean, meandering energetically. This trajectory is remarkable because of its mud flats, shoals, salt marshes and dikes which have been raised ever higher over the years. This landscape is wide and open, and human activities and nature are sometimes pitched in a front-line battle one against the other.

Tributaries and other branches

The area which discharges into the Scheldt covers a scant 22,000 square kilometres, considerably less than the Meuse and Rhine watersheds. In order of confluence, the Haine, the Scarpe, the Leie (or Lys), the Dender and the Rupel, with the latter being the confluence of the Zenne, Dijle, Demer and the (Major and Minor) Nete are some of the larger tributaries flowing into the Scheldt on French or Belgian territory. The Leie is the longest of these. Before uniting with the Scheldt in the centre of Ghent, it has wound through the northern French and Flemish landscape for more than 130 kilometres, although the latter should not be taken too literally since this little river has been canalised along large sections to facilitate navigation. The 250 locks and dams alone used to connect the river, its tributaries and canals to each other or rather separate them, already show to what extent the Scheldt watershed has been adapted to use by people.

Influence of the ocean

Immediately after Ghent, the effect of the ocean becomes noticeable with an average difference in tides of two metres. The total difference in level of about one hundred metres already lies behind at that point. From this point on the Scheldt takes on its estuarian character. That is until the mouth at a distance of 160 kilometres! The differences in water level caused by ebb and flood are impressive. The estuary has the shape of a funnel. The five kilometres that separate Vlissingen from Breskens narrow down to thirty metres at Ghent. The current of high tide which is pressed into this funnel pushes the water higher and higher. At the mouth, the difference between the tides is 2.5 to more than 3.5 metres in normal conditions. Those values are more than a metre higher around Antwerp. Continual western gales can considerably strengthen the tide as well as the funnel effect. The highest difference in tides so far was in November 1993, measured a little south of Antwerp, at 7 metres and 36 centimetres. This part of the river, which is clearly affected by the ocean, is not called the Zeeschelde [Sea Scheldt] for no reason. The tide even penetrates into the tributaries for a certain distance: 12 kilometre up the Rupel, 10 kilometres up the Zenne, 7 kilometres up the Dijle, 15 kilometres up the Nete and 16 kilometres up the Durme.

Estuary dynamics

One of the properties that make a large part of the Scheldt a unique river are its estuary dynamics. The forces and effects of the sludge-rich river water and the ocean on one another ensure gradual and continually changing transitions between fresh and salt, wet and dry, sand and soft sludge, rapid flow and almost stagnant water, protected areas and zones battered by the violence of the waves. These are the landscape-shaping forces which are still entirely intact in the Scheldt estuary. If they had totally free reign, they would, in a natural way, make continuously changing patterns of flood channels, ebb channels, parallel channels, short-cut channels, mud flats, shoals and salt marshes. These are the patterns in the landscape which determine the chances for all types of life to either settle in permanently or to be temporary guests. In an estuary the tide dynamics are the motor of the eventual quality of landscape and nature. The concept of ‘quality’ includes in this case the corresponding factors ‘diversity’, ‘completeness’, ‘uniqueness’.

Surface areas (ha) of the 3 most important types of habitats in the Scheldt estuary (channels, mud flats, salt marshes), divided into Flemish (Zeeschelde) and Dutch (Westerschelde) parts (Figure: Scheldt Information Centre/RIKZ)

	Water	Mud flat	Salt marsh	Total
Zeeschelde	3,000	656	518	4,174
Westerschelde	17,598	10,581	3,175	31,354
Total	20,598	11,237	3,693	35,528

However, the dynamics in the Scheldt estuary are no longer allowed free reign, however powerful they may be. The shipping channel is frenetically kept at its present location by dredging. Levees force the water here and there to flow in an unnatural direction. Reclamation of the salt marshes has taken away a large surface area of salt marshes from the river system over the years. This not only means loss of salt marsh landscape, but also reduction of the tide storage and the latter has a driving effect on the water levels.

Wooded flood area

In contrast to extensively channelled rivers such as the Rhine and Meuse, the Scheldt river system has still retained part of its natural condition. One of the essential characteristics of this is the presence of room to be able to flood land in case of voluminous water discharge. Water which can spread horizontally does not swell vertically, in other words: rivers that can flood are safe rivers if a layer of water cannot damage anything in the flood area. Selective agricultural use and living on hills or pilings is easy to imagine. If nature is given room, mud flats will be created along the banks which will develop into salt marshes as they fill up with sludge. Wooded areas will start to form on salt marshes which embark on a further stage of becoming land. If the river changes its course in a wooded valley it flows through, extensive wooded acreage can be flooded during high tide. Large sections of wooded flood areas still exist in the tortuous meanders of the Zeeschelde section between Temse and Ghent.

Salt marshes

The largest acreage that can be flooded, however, consists of salt marshes, high shoals of mud and sand immediately next to the main channel. They are intersected by shallow creeks or creeks that completely dry up, which branch into smaller channels which branch again, and so on. Depending on where they are situated in the salt, brackish or fresh-water zones, salt marshes have their own, but always particular, flora. The greater the difference between high and low tides, the more extensive and profiled the salt marsh landscape becomes. A purifying action is attributed to the salt marsh vegetation, especially due to conversion of nutrients dissolved in organic materials. For that matter, this vegetation consists of true power houses such as sea anemones, salicornia and couch-grass. They are resistant to strongly changing conditions like periodic flooding and the changing salt content. Boisterous growth of reeds dominates in a fresher water environment. The salt marshes are home to a great deal of life in an estuary. Research in a creek in the Verdronken Land van Saeftinge [Saeftinge Flooded Land] demonstrated the presence of about thirty species of fish, shrimp, crab, water fleas and sow bugs. Ducks, geese and stilt walkers use the salt marshes as resting, mating and breeding area. For other species they provide a place to flee to at high tide.

A wealth of birds in the Scheldt salt marshes (Photo: Jan v.d. Broeke, RIKZ)

Shoals

Salt marshes are created by sludge that is carried by the river and deposited at sheltered areas along the edges of the river bed. Shallow areas exist in the middle of the fast flowing water in the wider sections of the Westerschelde which were not created by sludge deposits but by transport of sand. These are the shoals. The sand stored in them is brought in from the ocean with the flood tide current. That current is actually more forceful than the ebb, with the result that ocean sand is flushed upstream in jumps. Another sustaining force for formation of shoals is the corkscrew motion made by the river in the bends. This causes sand from the outer bend to move over the bottom to the inner bend. Very extensive channels are often intersected by so-called short-cut channels.

Altogether, the estuary forms a highly dynamic system. Along with the salt mud-flat marshes, the mud flats, shoals and salt marshes make up one of the few Dutch landscapes of international significance. Their protection is established in the European Union Habitat Directive.

Brackish zone

During every tide enormous quantities of water go up and down. In Vlissingen this is more than a billion cubic metres of water in one 24-hour period. The discharge of river water is ten million cubic metres, on average. The ocean may drive the water in the Scheldt up to Ghent, but that does not mean that the salt water reaches that far. In the village of Schelle, ten kilometres south of Antwerp, salt water has never been observed, leading to another strange fact about the Scheldt. Between Ghent and Antwerp fresh water alone is moved up, a phenomenon which only used to take place in the

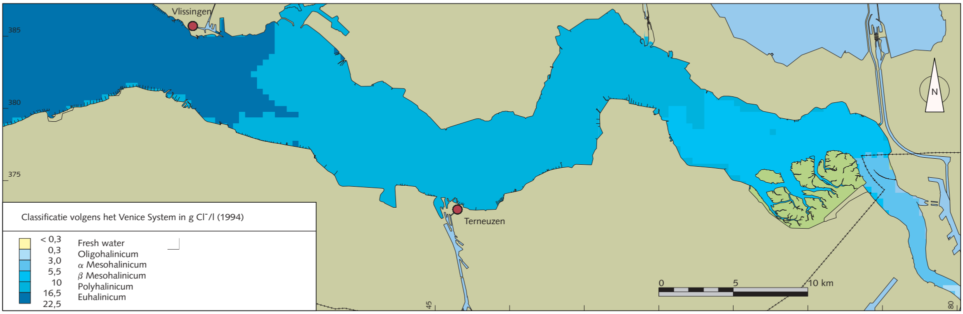
Hollands Deep and the Biesbosch on this scale in Western Europe, but which has now become a thing of the past since the Haringvliet was closed in 1970.

The Scheldt brackish water zone is situated roughly between Hansweert and Antwerp. Brackish means that the chloride concentration fluctuates between 19 grams per litre water (salt) and 0.3 grams (fresh). No permanent points delineating the brackish water zone can be given because all kinds of factors have an effect on the way the river and ocean water mix. For example, the Scheldt discharges more water after a period of rain, as a rain water river should, with the result that the salt concentration falls a bit. But in times of drought the Scheldt discharges considerably less water, allowing the ocean water to penetrate deeper into the interior. The salt water also penetrates further into the Westerschelde during spring tide - meaning around the full and new moon – and far less than during neap tide (around the first and last quarters). A storm at sea – especially one from the northwest - also pushes the ocean water further inland, while an offshore east wind has the opposite effect.

Human habitation

Just as with any river on Earth, the Scheldt has a very strong attractive power over people. A river ending in an extended estuary provides, other than water and means of transport, fertile soil and a multitude of food sources also. Thus it is no wonder that since earliest recorded history people have settled up to the boundaries of the Scheldt estuary. One of the oldest writings about this dates from the beginning of our calendar, when the Scheldt still ran a very different course. The Roman commander Plinius reported in the year 42: *"At that place, the ocean rushes across an immeasurable area twice every 24-hour period. In this eternal fight in nature's course the question arises whether the soil belongs to the land or to the sea. A poor people lives there on high hills, or rather on heights they built by hand. They have built their huts on top of these. They become sailors when the water covers the area, but shipwrecked people once the water has receded. Then they hunt the fish that try to escape along with the water. They keep no livestock and thus cannot nourish themselves with milk. Neither do they manage to catch any wild animals, since the ocean has flushed away all vegetation near and far. They make a kind of rope from reeds and rushes which they use to make fishing nets. The only drink they have is rain water saved in pits in the halls of their dwellings."*

Fresh-salt distribution in the Scheldt estuary (Figure: Scheldt Information Centre/RIKZ)



Safety

The people Plinius encountered at the outer edge of the land literally lived with the water. In all the stages of development which were to follow, people living around the Scheldt have tried to keep the water out of where they lived, even if only to have dry feet and to be able to grow plants. The first dikes were built, followed by higher ones, for the water broke through time after time. Then the people living within the dikes who had no longer arranged their farms, villages and cities to take the water level into account were surprised. Paradoxally enough, each time an area was diked in, the tide storage was reduced, resulting in even higher water levels! Disasters followed. In every century there were one or more critical situations or floods. In the past century this happened, for example, in 1953, 1976 and 1998. The first two times involved ocean water being whipped to unprecedented heights; in 1998 excessive rainfall caused a situation where the bed of the Scheldt itself was insufficient to hold the water.

Sigma plan

Zeeland in particular was hit in 1953. It is true that many dikes along the Zeeschelde also ruptured, but, amazingly, “only” five people drowned. In contrast to the Netherlands, where there were more than 1800 casualties, the Belgian government saw no reason to institute a voluminous dike reinforcement program. However, when a similar flood happened again on January 3, 1976, Flanders got its own Delta plan. It was named after another letter of the Greek alphabet: the Sigma plan (sigma means support, trestle). The first component was raising the dikes in the entire Zeeschelde basin. Since then the reinforcement of that 512-kilometre dike has just about been completed. Less than one hundred kilometres has yet to be done.

Controlled flood areas

Since the prediction is that those higher dikes will also not always be able to withstand the danger, the second component of the Sigma plan is the creation of controlled flood areas. Polders in the former winter bed of the river, nearly devoid of buildings, are surrounded by a ring dike of which the side along the river is kept the lowest. At high water level, the river can flow over this low dike and ‘park’ part of its load in the polder without having to chase people away from their hearths and homes. In places where this is important, the risk of flooding must be reduced. Thirteen of such controlled flood areas have been planned. Of those, twelve are already in use, together covering about 533 ha. These are situated both along the Scheldt and its tributaries.

The last and by far the largest controlled flood areas is planned for immediately south of Antwerp, along the west Scheldt bank. At Kruibeke, Bazel and Rupelmonde various polders covering 580 hectares in all have been assigned for this purpose. The preparations have meanwhile advanced to the point that a first, although relatively small, component has been put into operation.

Construction of storm flood barrier doubtful

In its original design, the Sigma plan also provided for construction of a storm flood barrier at Oosterweel, a bit downstream from Antwerp. However, this barrier has been controversial since the beginning and it was decided already in 1985 to postpone its construction. This decision was mostly based on financial considerations. Later studies have also added technical doubts to this. A structure that must be resistant to pressure differences of water levels that may rise and fall many metres with each change of the tide needs a solid foundation. The question is whether the loose substrate on which the barrier would be placed could support the colossus. The definitive decision of abandoning the construction has still not been made, but the updated 2001 Sigma plan states that safety in the Zeeschelde basin can also be increased in a different way. Creating strictly controlled flood areas, especially in the upstream part of the estuary, would bring about the same effect as the storm flood barrier. For this purpose the grounds along the Durme tributary, which flows into the Scheldt at Temse are being considered.

Different safety approach

The adjustment of the Sigma plan also contributed to the long-term vision for the entire Scheldt estuary drawn up by the Vlaamse Administratie Waterwegen en Zeewezen [Flemish Waterways and Ocean Affairs Administration] (AWZ) and the Netherlands Water Authority Zeeland management. They did this under contract with the Technical Scheldt Commission (TSC), a Flemish-Dutch co-operation for the Scheldt that had already been founded in 1940. In this vision, described by TSC in 2001, safety is approached differently. Water control plans must no longer be designed on the basis of protection from high water, but on the basis of protection from damage. Moreover, safety from floods is no longer the only important issue in the long-term vision, but the accessibility to all harbours along the Scheldt and the natural state of the physical and ecological systems have become just as important. The vision formulates the target image as follows: “In 2030, the Scheldt estuary must be a healthy and multi-functional estuary water system being used in a durable manner for human needs”. Integral water management has thus set in in the management of the Scheldt.

From river to waterways and sewer

10

The long way to the ocean

In the previous chapter we discussed the curious course away from the ocean that the Scheldt takes after it reaches Ghent. The explanation for that detour to the ocean can be found in the distant past. Two million years ago Flanders was covered by a shallow sea with an east-west coast line, at the location where Ghent and Mechelen are now situated, before curving to the north. All sorts of little rivers flowed into that sea, all of them coming from higher grounds to the south. When the seas retreated northward at the end of the interglacial Tiglien, the Leie, Scheldt, Dender and Zenne also extended their courses in that direction.

In the thousands of years to follow, the much bigger rivers Rhine and Meuse extended their fan of debris into that sea and raised the bottom. Thus there was no other solution but for the small "Belgian" rivers to shift their mouths westward. In addition, the eastern most of these were blocked by the Brabant Massif which was raised as a consequence of ground movements that started in the Tertiary and continue to make themselves felt even now. The small rivers united at the southern edge in what is now called the Rupel and flowed westward to where the Brabant Massif stopped (at the location of St. Niklaas). Only there could they flow northward into the sea along with the Scheldt and the Leie.

In the last glacial period this Flemish valley was filled in with sandy deposits which were blown by the wind in dry times to form sand ridges. In the long run these blocked the rivers' exits into the sea, assisted by the streams having little water to discharge.

Tributary of the Rhine

When the Rupel consequently had the chance to force a break-through in its course towards the north and wore away a small valley through the Brabant Massif, the Scheldt and Leie took possession of the western Rupel and started using the same way out the Rupel had found at what is now Kruibeke. To do this, they did have to flow eastward for a stretch. About the end of the last glacial period, the Weichselien, the North Sea had retreated to its northern part and England was attached to Europe. Along with the Thames and the Meuse, the Scheldt was then a tributary of the Rhine, which flowed into the North Sea as far as the Doggersbank.

A mouth of its own

The next change in the course of the Scheldt took place in the Holocene, when the ice pack had retreated round the poles. The oceans and their marginal seas were filled with water melting from the ice. Sometimes slowly, other times rapidly, the North Sea coast line shifted southward and eastward. About 5500 years ago all of Zeeland – with the exception of Zeeuws Vlaanderen – consisted of a large tidal area of shoals, mud flats, salt marshes, tidal inlets and a few beaches. The Scheldt flowed along the extreme eastern margin of this, through the area now called the Eendracht, on its way to the Meuse, of which it was still a tributary. But that was not to last another thousand years, for the sea pushed further and further until a sea inlet – let's call it the Oosterschelde for the sake of convenience – reached as far as the

Scheldt, giving the river its own mouth and thus ceasing to be a tributary. The Scheldt would use this Oosterschelde estuary until the aftermath of the Romans, in the fourth century of our calendar.

Delta

The departure of the Romans coincided with the beginning of a period of rapid rise of the sea level. Zeeland, where a thick layer of peat had formed in that previous period of slow rise in the sea level allowing a relatively large number of people to settle on it, was exposed to one flood after another. Large areas of land were washed away and the estuary of the Scheldt turned into a delta. The most southern branch of this flowed into the ocean at what is now Vlissingen and over the course of centuries this ocean inlet grew into what is now the Honte. In the on-going, unremitting process of sludge being deposited, crumbling away and shifting channels, this ocean inlet had moved east about the year 1000 to such an extent that it already connected with the Scheldt round Woensdrecht and Ossendrecht, and since then commenced to flow more and more via this route, and less via the Oosterschelde. By constructing the dam between South Beveland and Brabant – to accommodate the rail between Bergen op Zoom and Vlissingen – in 1867, there was no other way the Scheldt could discharge its water but via the Honte, or Westerschelde, as this ocean inlet was eventually called.

The period of extensive intervention

Closing the Kreektak with a dam and thus tying off the Oosterschelde as a branch of the Scheldt was the umpteenth intervention in the course of the river since people settled along the coastal strip. This does not refer to the prehistoric hunters and gatherers who fanned out over these regions when the climate warmed up after the most recent glacial period. Their lifestyle did not have any effect on the landscape along the Scheldt or on the river itself. This changed when farmers entered upon the scene more than 6500 years ago and started cutting down the woods along the banks. The resulting erosion affected the transport and sedimentation behaviour of the river. However, these changes were not nearly as drastic as what was to follow many centuries later.

The Romans were probably the first to build bridges and use the Scheldt as a navigational route. The Normans who terrorised the low lands on the sea in the eighth and ninth century did the same. Their ships took them far up the river. In Ghent they burned the Saint Bataaf's Abbey about 850, after already having destroyed Antwerp once in 836. Yet this first millennium after Christ can be considered as a period during which human influence on the environment remained limited in scope.

Large-scale clearing

Only after the Normans had finally been put in their place and the region became safer did more people have the courage to settle there, and large-scale clearing of the banks and the land farther away from the river got well under way. South of Ghent the wooded acreage disappeared nearly entirely in the course of the Middle Ages, causing the river discharge to become more irregular. High discharges in the winter alternated with low discharge in the summer half of the year. The winter discharge was associated with floods and sedimentation in the flats downstream from Ghent. A pattern developed of raised banks with sandy deposits right next to the river, with clay basin land behind it. This flat and fertile alluvial soil was also very suitable for agricultural use. Throughout the centuries, the number of settlements increased and as they became economically more important the necessity to protect them also increased. Around 1100 the first dikes were constructed, a novelty which was soon copied elsewhere.

However, those very dikes which provided protection to the land behind them made other areas less safe. Reduction of the acreage the river could freely flow through led to faster currents and those in turn led to widening and deepening of the river bed. Since the sea level also continued to rise, parts of the river that had never been exposed before were exposed to high and low tides. A good example is the Temse region, where a bend of the "old" Scheldt has been preserved. In comparison with the current Scheldt, which is 10 metres deep and 250 metres wide at that spot, the old, tide-less river was just a 75-metre wide insignificant stream, only a few metres deep.

Give and take

Enclosing fields and meadows did provide some, but not absolute, protection. Under extreme conditions the water rose above the top of the dike and the ocean and the Scheldt once again claimed the flood areas that had been taken away from them. Especially between 1350 and 1600, a period with many storm floods, many a polder perished. The heavy storms which led to the Saint Elisabeth Flood of 1430, the Saint Felix Flood of 1530 and the All-Saints Flood of 1570 are infamous. The polders north of Antwerp which were lost at those times were not protected by dikes again for a long time. The reason for this was that the bottom of the reclaimed polders had dried out or that the ground level had dropped as a result of digging for peat and of extracting both salt and clay (for the brick industry). In combination with a rising sea level this caused the cultivated ground to have sunk even deeper below sea level, making it difficult to reclaim it after a dike broke through. This is how it came to be that the Scheldt reached its largest tide storage surface area at the end of the sixteenth century.

Smaller tide storage

However, from the sixteenth century on the construction of dikes gained momentum again – stimulated by prosperity and new technology. The water was slowly pushed back. This phase of reclamation of land only came to an end in the course of the twentieth century. Nowadays roughly one-third of the 45,000 hectares covered by the Westerschelde in 1880 has been converted into harbour and industrial terrain, farmland, grass field or dike-enclosed nature reserve, mainly in the Loe area, the Braakman, the Hellegat around the Land of Saeftinge and in the Kreekrak area. The entire surface area of the Zeeschelde also shrank by about one-third during that period. It may be true that the complete 35,000 ha estuary with its mud flats and salt marshes remains an impressive area, but withdrawing 1/3 of the tide storage area from the river system has caused severe effects on the natural state of the system and the water levels in the eastern part.

Development of navigation

Not only the construction of dikes has changed the appearance of the Scheldt. There has also been drastic intervention in the river to improve shipping. The Scheldt and its estuary only solidified their role as shipping route in the course of the nineteenth century. Doing away with the Scheldt toll in 1863 gave shipping an enormous impetus. One year later 2753 ocean-going vessels already moored in Antwerp. One of the first acts of intervention in the course of the Scheldt took place in Antwerp itself. Beginning in 1870, the Scheldt quays were straightened and a considerable part of the old city was demolished for this. Without mercy, a strip of one hundred metres of building structures over a length of almost one kilometre, including the city wall, the St. Walburge church and a large part of the Het Steen castle, was demolished to make way for a new, straight quay wall and a wide quay.

More and larger harbours

Following this, one harbour dock after another was dug immediately north of the city, including the Kempisch and Asia docks (both in 1873) and the Suez, Lefebre and America docks (all in 1887). In the twentieth century there seemed to be no end to the growth of the harbour area. The inlet basins and the locks providing access to them became bigger and bigger. The new harbour and industrial areas also ended up farther from the city. As the conclusion of the first large expansion, the Kruisschans locks were inaugurated in 1928 (renamed the Van Cauwelaert locks in 1962). These locks are situated in the extension of the straight section of the Scheldt up-stream from Lillo, which saves the captains and pilots from having to negotiate the two ninety-degree bends between Lillo and Antwerp. In the sixties a subsequent, even larger-scale project began: transforming the strip of land between Zandvliet in the north and Ekeren in the south. The colossal Churchill dock and the Kanaal docks B1, B2 and B3 of the same size were dug there. The Zandvliet locks were built for the access of ocean-going vessels not far from the Dutch border, and the Scheldt-Rhine canal was dug for inland navigation. This canal, which more or less follows the course of the Scheldt of the distant past when it was still a tributary of the Meuse, provides Antwerp with a good connection to the Ruhr region.

The result of this passion for expansion was that the entire Scheldt bank north of Antwerp up to the Dutch border had changed from polder land into industrial harbour area by the end of the twentieth century. And that a similar process had gained momentum on the other bank. Beyond the Kallos locks (built in 1976), the Noordelijk and Zuidelijk inlet docks, the Doel dock and the Vrasen dock have been constructed. The Verrebroek dock and the Doorganck dock are still in the plans. Due to this new expansion of the harbour area, the existence of the village of Doel is in jeopardy.

Dredging operations

Moving the harbours in the direction of the ocean has never liberated Antwerp from the fear of the harbour access route becoming blocked by sludge deposits. To what extent that fear has existed is clear from the seven hundred publications which appeared on the navigability of the Westerschelde between 1830 and 1900 alone. The only possible way to counter the natural process of sedimentation was to keep the navigation channel at the right depth. There were steam dredges operating in the Scheldt already in 1850, but the number of dredging vessels only reached fleet level after WW II, when the Scheldt had to be accessible by ships with deep draft at low tide also, in order to compete with other harbours.

Meanwhile, old-fashioned dredges no longer exist, making way for sand suction dredges to maintain the navigation channels. In place of rotating motors with large buckets installed on a conveyor belt scraped the sand from the bottom and emptied them into holding barges or split barges moored

Dredging operations in the Scheldt (Photo: Jan v.d. Broeke, RIKZ)

next to the dredges, modern sand suction dredges pump the sand sucked from the bottom directly to a depot on land via transport pipelines.

But whatever method is used, once dredging is begun it must be kept up, because removing shallow areas actually causes an unnatural situation which the river strives to undo as quickly as possible. This is especially true for the access channels to the locks leading to the harbour docks closing up in no time at all due to sludge deposits, because these quiet sections of water, where the current is slower than in the Scheldt itself, are true “sludge collectors”. To maintain the depth of these channels, a special “rotational sludge scraper” was developed: a push-bucket-type vessel lowers a steel blade to the bottom at low tide and uses this to push the sand back into the Scheldt.

Sludge problems

In the first few years one knew what to do with the sand dredged from the river. It was perfect for filling in other harbour terrain. But as the Scheldt water kept getting more contaminated, and along with it the sludge that settled on the bottom, problems were created. Not so much on Flemish territory where the subject was not so important until the end of the twentieth century, but rather on the Dutch part of the Scheldt estuary.

A permit is necessary for the permanent dredging work which Flanders implements on Dutch territory. In the nineties, the Ministry of Waterways and Public Works included the condition that the Maritime Scheldt Department of the Ministry of the Flemish Community had to take a certain quantity of contaminated sludge from the Zeeschelde annually in order to limit adding this contaminated river sludge to the Westerschelde. That quantity – set at

300,000 tonnes of dry matter per year – was dredged until recently by the Flemish from the access channel to the locks near Kallo. Thus the sand was not pushed back into the Scheldt in this case, but transported to a depot consisting of a few deep pits in the Waasland harbour near Doel.

However, this removal had an unexpected side effect: the quality of the sludge carried by the Zeeschelde into the Westerschelde deteriorated. It contained more heavy metals and organic micro-contaminants than ten or so years before. This was strange since remediation of the discharge, which had unquestionably gained momentum, was supposed to produce cleaner sludge. The “Cleaner Scheldt Due to Sludge Removal” report, which was published in 1998, gave the following explanation: near Kallo, more sludge was removed than the river delivered, with the result that sludge was “soaked” from the river bottom and part of it was carried into the ocean. This sludge from the seventies is more contaminated than what the Scheldt has been discharging in the recent past. Mixing the latter with the old sludge was the reason the measuring results showed deterioration. For that reason, the stipulation from the permit was adapted in 2001: from now on, the Flemish will dredge contaminated sludge from a different part of the Scheldt, upstream, or from a tributary. The sludge from the access channel to Kallo will be pushed back into the Scheldt from now on, just as at the other locks.

Thresholds

The fact that ocean-going vessels became bigger caused the Antwerp port authorities to set more stringent requirements to the width and depth of the shipping channel in the Westerschelde. The Belgians had already started dredging around 1900. At that time the object was still mainly to level the thresholds in the eastern part of the Westerschelde such as the ones at Valkenisse, Bath and Zandvliet. The thresholds of Hansweert, Baarland and Borssele, the shoals of Walsoorden and the Hansweert overflow were gradually added to these.

Thresholds occur in all channels of the Scheldt estuary. They originate in the transitions in the bends, where the flood and ebb tides are not concentrated in the same part of the channel and sometimes even form separate side channels. At ebb tide the bed is usually deeper and forms a continuous channel in the clearest manner. At flood tide, the bed is different from this and transforms into a branch channel, also called flood tide shear. At times the ebb and flood tide beds are a continuation of one another, at other times they run parallel to each other. The transition area is formed by a shallower plateau, the actual threshold. Thresholds are naturally about five metres shallower than the channels, but due to intensive dredging they can barely be recognised nowadays.

Deepening the navigation channel

In 1995, Flanders and the Netherlands signed a treaty on enlarging the navigation channel. Until that time, dredging was done on the basis of “44/40/34 feet”. That means that ships with a maximum draft of 44 feet can sail to Antwerp in one tide; that ships with a maximum draft of 40 feet can sail from Antwerp through the Westerschelde and that ships of a maximum draft of 34 can sail in the Westerschelde independent of the tide. According to the treaty, those numbers should change to 48, 43 and 38 feet, respectively. To make that possible, shipwrecks and other obstacles are removed, in some

Container shipping in the Scheldt (Photo: Jan v.d. Broeke, RIKZ)

places the shipping channel is enlarged and the edges of the channel are reinforced. These operations were begun in 1997.

The sand dredged up in this operation is re-deposited in other places in the Westerschelde. This keeps the costs relatively low and has the advantage that the sand is not removed from the natural system. On the other hand it means that the sand quickly returns to its old spot. That is why new dumping areas are designated which lie more westerly, closer to the mouth.

All the developments together have led to the fact that a lot more dredging is taking place. At the end of the sixties of the last century the annual amount of dredging implemented for maintaining the shipping channel to all harbours along the Scheldt was only 4.7 million cubic metres; now this has increased to nearly 14 million cubic metres.

Contamination over the years

The time when clean water flowed through the Scheldt is long past. But thinking that pollution is a side effect of the Industrial Revolution and only became noticeable at the end of the nineteenth century for the first time is a misconception. The quality of the water was already in sad shape in the Middle Ages, albeit at that time the scope remained limited to the surroundings of the cities and the water had a chance to clean itself to a certain extent before reaching the next population concentration.

City residents in those times considered the water flowing by them an easy way to rid themselves of their garbage. Waste from offal, food scraps, carrion, but also the non-organic waste from tanneries, dying operations, (copper) smithies and other traditional crafts, everything was dumped into the river.

The use of the river as rubbish bin was not without its consequences. Archaeologists are of the opinion that to this day they can demonstrate proof of this. They can deduct what people ate from meticulous studies of the contents of cesspits. From this they have been able to conclude that certain species of fish appeared ever less frequently on the menu of city folk and that only eel continued to have a prominent place throughout the centuries. Eel is a species of fish that can most effectively resist organic pollution.

Even though pollution has been around for a long time, it has unmistakably gotten worse with the advent of industry. What started in the nineteenth century with textile and metal factories in the meantime comprises the entire range of industrial activities. This occurred at a rapid pace especially after WW II.

The black years

The Belgian government encouraged the arrival of foreign investors by setting up the Ten-year Plan for the Port of Antwerp in the middle of the fifties. And it was successful. Esso and SIBP (now called FINA) opened refineries, and companies such as Petrochim, Cobénam and Amoco Fina built chemical factories on the right bank of the Scheldt. In the middle of the sixties, chemical giants Solvay, Polysar, Bayer, BASF, Monsanto and Degussa joined this group. Up to the seventies this progression expanded, in this case with Petrofina, Exxon Chemical, Bayer, BP, Union Carbide (now called Praxair Production), 3M, Rhône-Poulenc, Halterman and the most recent one, in 1978, the German Henkel (later renamed Aqualon/Hercules).

The zone along the Ghent to Terneuzen canal was also a favourite of all kinds of companies, and Dow Chemical built a plant at the mouth of the Westerschelde. On the opposite side of the Westerschelde, the Sloe turned into an industrial area. Finally, the nuclear power plants of Borssele and Doel arose at a fairly short distance from one another.

Precisely in those sixties and seventies, the environmental awareness of companies had yet to "awaken" and it was more the rule than the exception that waste water disappeared into the (Wester)Scheldt via a simple discharge pipe.

The water quality deteriorated after 1960. The companies associated in VIBNA (the North Antwerp Industrial Business Association) alone discharged more than 3 million resident-equivalents of oxygen-bonding substances in the beginning of the seventies. Part of the Zeeschelde and the Westerschelde were nearly devoid of oxygen and thus dead.

A changing tide

The Club of Rome report and the Surface Water Pollution Act taking effect in the Netherlands (1972) meant a turning point. From 1980 on, sewage purification plants were put into operation at Bath, Waarde and Vlissingen, among other places. Companies such as Hoechst (in Vlissingen) and Dow (Terneuzen) reduced their discharge of cadmium and lead, or benzene, respectively, while their production increased in spite of that.

In Flanders the 1971 Framework Act to protect the surface water from pollution (VLAREM I and II) led to reduction of contamination of surface water by industry, even though some stimulation was necessary for this, for example, by environmental organisations like the Stichting Reinwater which pointed

A view of the Antwerp industrial area (Photo: Jan v.d. Broeke, RIKZ)

out the abuse to the public at large. The publication of the “Belgium, Waste Water and Policy” report (1992) was one such stimulation. A single quote illustrates the necessity: “Various companies discharge their waste water from the De Bruwaan industrial area in Oudenaarde into the Diepebeek via two collectors (...) so that for years the brook has been drawing a red line through the landscape as a symbol for failing policy. The discharge is characterised by high concentrations of heavy metals, phenols, organic chlorine compounds and styrene.”

In some cases a lawsuit, an injunction and appeal were necessary to force companies to abide by the permits. Such was the case for Sopar Chemie in Zelzate, for example. This company, which processes coal-tar into raw materials for medications and colouring agents, started construction of a new purification facility during the process, after which the concentration of PAH was reduced to the maximum level allowed in the permit.

Before these first initiatives actually also led to visible results, the Scheldt would still provide a sorry sight for many years. In the beginning of the nineties, a black ribbon continued to meander through the beautiful landscape between Ghent and Antwerp, giving off the stench of decay.

From sewer pipe to clean water stream

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Treaty concerning the protection of the Scheldt

On April 26, 1994 the moment had arrived. The governments of France, the Netherlands, the Wallonian Province and the Brussels Capital Province signed the Treaty concerning protection of the Scheldt. The Flemish provincial government also signed in January of the following year. By signing the treaty, they accepted the obligation to collectively reduce the pollution of the river. The parties agreed to have the principle of precaution be their guide. That means that the control and reduction of contamination at the source must be given priority. Furthermore, they use the principle that the polluter pays the bill.

The International Commission for the Protection of the Scheldt

The task of the International Commission for the Protection of the Scheldt (ICBS), which was created at the signing of the treaty, is, among other things, to collect data about the sources of contamination and setting up target objectives which must maintain and improve the Scheldt ecosystem. The ICBS must also serve as framework for the exchange of information about the water policy and the projects which have a cross border effect on the Scheldt water quality. Finally, it must stimulate the participating parties to co-operate in carrying out scientific research in the areas of physics, chemistry and ecology and in studying the fish stock.
Immediately after being created the commission set up three work groups: ‘Water quality’, ‘Emissions’ and ‘Cross-border co-operation and combined living environment projects’.

Within the Emissions work group, the sub-work group ’Disastrous contamination’ was set up. The work groups must provide the building blocks for the Scheldt Action Program.

Scheldt Action Program

Right at the end of 1998, the ministers of France, Wallonia, Brussels, Flanders and the Netherlands involved in the process presented the first action program, which is particularly focused on the short term: the years until 2003. Most of the actions are especially intended to improve the water quality of the Scheldt, the oxygen balance in particular.

At the time the ICBS was set up, the water quality could quite frankly be termed poor. The explanation for this is that for a long time the river was considered, like most waterways, as a natural route of discharge for all waste, both liquid and solid. Most people assumed that the dilution was on a big enough scale that serious contamination would not take place. Furthermore, they attributed a higher auto-cleansing capacity to the river than it actually possessed. It was also very human not to pay any attention to the consequences of the production process on the environment when seeking the lowest possible production costs. Add to this the fact that the watershed of the Scheldt comprises the most densely populated areas of Europe, where agriculture is an intensive process, where many (chemical) industries have settled, where a lot of transportation takes place – not only of passengers, but also of goods – and it becomes clear that the waste flow is considerable.

The maps of the biological water quality and oxygen quality of the Flemish part of the Scheldt which were included in the first ICBS report (of 1994) manifestly demonstrate this point. On both of these the red colour for hazard is predominant, the safe green colour only appears in the legend. The map of the biological quality indicates that it can be qualified as poor (light red), or even very poor (dark red) for the entire river, with the exception of two small – yellow – areas downstream from Ghent. The map of oxygen balance only requires the red colours to indicate the differences: light red for “polluted” and dark red for “severely polluted”.

Homogeneous Scheldt measuring network

At the installation of the International Commission for the Protection of the Scheldt (ICBS), the member nations decided to set up a homogeneous measuring network in order to be able to determine the water quality and follow the changes.

It was not an easy task to arrive at such an unambiguous measuring network, because measuring substances implies that objectives must be set and that if the measurements turn out to be higher, measures will have to be taken to meet the objectives. That is why it was decided not to measure more than the nutrients nitrogen and phosphorus and the oxygen concentration in the first few years. The homogeneous network was expanded over the years to include heavy metals cadmium, copper and zinc and a few PAH and pesticides lindane, atrazine, simazine and – starting January 2001 – dimazine.

The European Water Framework Directive will result in further expansion of the measuring network. ‘Brussels’ is expected to impose the obligation to also add the list of substances which in fact should already not have been allowed in Europe to the measuring program.

There are also differences in opinion on the method of measuring. There are countries that think that the European standards must be used, others take the position that the method may be left up to the particular country provided the results can be compared with one another. In practice, it boils down to the fact that the second method will be applied and the system of ring tests – meaning that each laboratory has its results checked by a series of others – will safeguard the “comparability principle”.

The homogeneous measuring network now comprises fourteen points between source and mouth of the Scheldt. Once every four weeks samples are taken at each point. This only involves water samples, the sediment is not included in the monitoring. There is also some disagreement about this within the ICBS: some countries are of the opinion that sludge and sediment should properly be part of the measuring program because a lot of contaminants attach themselves to them.

First positive points

In its first report in 1994, the ICBS concludes that the quality of the middle section of the Scheldt in particular is poor. The commission points the finger at the tributaries Haine, Scarpe, Spierekanaal, Grote Spierebeek, Zwarte Spierebeek and Rupel. The two positive points downstream from Ghent are attributed by the ICBS to the efforts by government and industry to take remediation measures. The recovery is in any case not a result of the supply of clean clear water from the Leie. That water is just as dirty, but is quickly channelled to the Ghent-Terneuzen Canal with some of the Scheldt water after having dumped itself into the Scheldt at Ghent. In other words, it cannot counteract the “recovery” which the Scheldt water is experiencing over a short part of the river’s course.

The improvement that was detected downstream from Antwerp in the beginning of the nineties was caused, according to the ICBS, by the tidal effect which diluted the water.

The first ICBS report concluded with the observation that an important part of the total emission in the Scheldt watershed was caused by non-purified discharges. One may cherish the hope that the worst is over from the sentence that follows this statement: “All parties to the treaty are implementing large investment programs that are partly focused on meeting the objectives from the European Directive for treatment of urban waste water.”

Further remediation

At the beginning of the new millennium it can be concluded that progress has indeed been made. The degree of purification – the percentage of residents whose waste water is purified effectively at a sewage purification plant – which still was only 27 percent in 1985, had already increased to 38 percent by the middle of the nineties and is now 50 percent.

According to a summary of the Flemish Environment Association (VMM), more than eighty purification plants were built in the nineties and after 2000 another ten were put into operation. This brought the total number of sewage purification plants in operation in the Flemish part of the Scheldt watershed at the end of 2000 to 180. An additional 130 are projected, of which most, though, will not have as much capacity as the existing ones. The Flemish government approved the 2002-2005 (2006) multi-annual program in June 2000.

A dozen sewage purification plants were put into operation in France in the nineties and fifteen were modernised in such a way that they are also capable of removing phosphate and nitrogen from the effluent.

In the Netherlands no additional sewage purification plants were added in the nineties. However, the eleven plants which discharge into the Westerschelde are or will be equipped with technology which can remove more phosphate and nitrogen. This raises the efficiency of the sewage purification plants at that point from 45 to more than 75 percent. The Hulst sewage plant is the next to undergo such a modernisation. In addition to that, the Zeeuwse Eilanden [Zeeland Islands] and Zeeuws Vlaanderen water authorities are making an effort to connect the many hundreds of remote farms and houses to the sewage system. Should this prove unprofitable, considering the costs, ibas (Dutch term for individual waste water treatment installations) will be installed. In 2005, not one housing unit may discharge untreated sewer water into a polder ditch or outdoor water.

Effect on nature

The first visible signs that the Scheldt has become cleaner are there. Some bird species have clearly increased in numbers. A considerably larger number of green-winged teals have been counted, the number of gadwalls has tripled and the pochards, of which several hundred specimens, at maximum, were spotted at the Zeeschelde in the early nineties, now appear in numbers over several thousand. Wild ducks, northern pintails, tufted ducks, coots and shelduck are also seen in larger numbers. The increase in green-winged teals is probably related to the population explosion of worms (Oligochaeta) which have been found in the mud flats of the fresh-water tidal areas.

Another indication is the recovery of the twaite shad population downstream from Antwerp. In 1996, for the first a fisherman from Lillo time found three May fish, as twaite shad are called in the vernacular, in his nets when he brought them up in the bend of Bath. Meanwhile, that number has increased to more than 200. A similar development is demonstrated by the observations which are made at the cooling water inlet of the nuclear plant near Doel.

Dying fish at inlet points

Inlets for cooling water are infamous because of the amount of fish they kill. Young fish in particular are not capable of resisting the strong current and are sucked into the factory or power plant where they collide against grids or filters. Even if they survive this, they will return to the river wounded and often still die.

The nuclear plants of Doel were known as big fish killers until recently. The number of fish and shrimp which were killed annually is no less than one hundred million. A large portion of these were young fish, which can partly be explained by the fact that the Zeeschelde is the hatchery for many fish species. In the spring, migratory fish such as turbot, sea lamprey and thick lip grey mullet ended up on the grids. In the summer mainly crab and shrimp were killed, while the winter months showed more herring, smelt, sea bass and many fresh-water fish species. All these animals were collected in a container and eventually incinerated.

Shrimp, crab, flounder, eel, stickleback and sea lamprey usually do survive the trip through a pumping station because they are “bottom dwellers” and can take some punishment and endure the none-too-gentle contact with the grid bars. However, herring species incur infections after any type of contact, killing them within a few hours. Black goby that return to the river can endure a bit longer, but still die after a few days due to stress or the injuries they sustained.

Fish guiding system

To put an end to the enormous number of fish dying in the water pumping station of the nuclear plants in Doel, a fish guiding system which operates by sound has recently been commissioned. The system consists of 24 boxes which broadcast a strong sound signal (175 decibels) at high frequency. The noise must scare off the fish and keep them away from the inlets. Fish with swim bladders are especially sensitive to sound as this organ picks up vibrations.

Tests have demonstrated that the number of fish sucked into the installation has been cut in half. Herring in particular benefit from this: their number was reduced by 95 percent, while sea bass and smelt showed a reduction of 90 percent.

Fish and shrimp which pass through the mesh of the repulsion system anyway return to the Scheldt faster after the recent adaptations made to the pumping station, reducing the risk of injury. All in all, the impact of the power plants on the fish and shrimp populations has been reduced by 90 percent.

The presence of twaite shad in the Scheldt can be nothing other than an indication that the oxygen concentration has increased, because this fish will simply disappear if the oxygen concentration is less than 3 mg/l^{-1}.

Seals

Another indication that the water quality is improving may be the number of seals counted in the Westerschelde. In the remote past they were numerous, but in the second half of the eighties one could count them on the fingers of one hand. There was a slight increase in the following years, until they numbered more than ten in 1995. At this time there are twenty of them, but because seals were also introduced in 1997, that increase cannot be attributed to improvement of the water quality alone.

The actual quality of the Scheldt water

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Environmental legislation

The worst is over. It is true that the time when the water of the Scheldt used to flow towards the sea black and stinking is not over yet, but remediation of discharge by companies and the construction of sewage purification plants has permitted one to see improvement.

Environmental legislation took care of this. For example, the amount of waste discharged was reduced spectacularly at 527 companies in Flanders. Jointly they produced almost half of the total emission of companies where debit and concentration observations take place. A few numbers: between 1992 and 1996, the amount of discharged floating matter was reduced by 95 percent, that of heavy metals by 67 percent and the quantities of nitrogen and phosphorus by 43 and 31 percent, respectively.

The oxygen balance has also improved. Yet such successes are no reason to sit back and relax. That should be obvious from the summary below of a few substances which even now continue to be measured in the Westerschelde environment and which are obstacles in the way of the ecosystem functioning in a healthy manner.

PCB

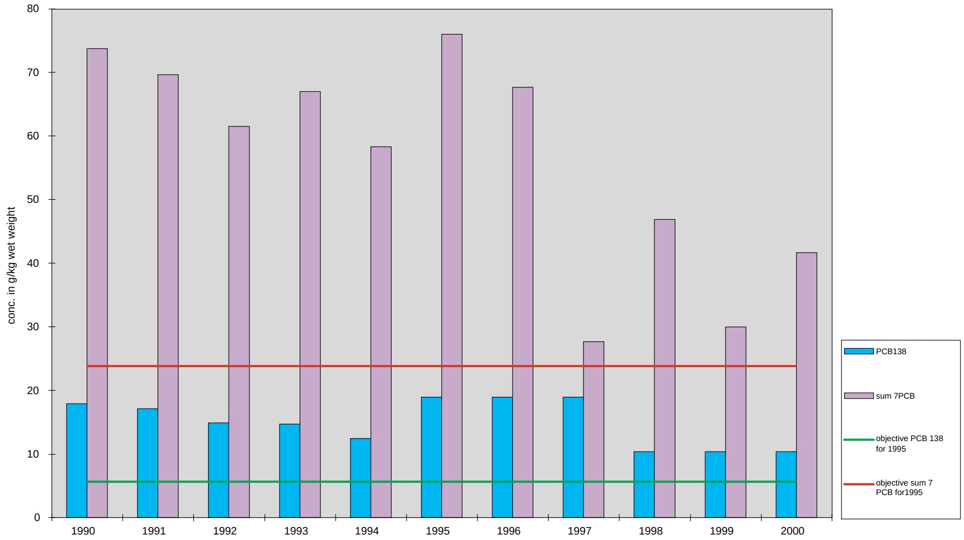
PCB (Polychlorobiphenyl) is the collective name for 209 closely related – mostly poisonous – substances classified in the organic micro-contaminant category that also includes the PAH (see below) and pesticides. Each individual PCB is given a number which is higher as the percentage of chlorine increases.

PCB do not occur naturally, but because of their many applications in lots of products they were distributed abundantly throughout the environment over the years. To a large extent this is the result of leaking transformers and hydraulic systems. Once they end up in the environment it is difficult to remove them as they do not dissolve easily in water. Moreover, the degree to which they do dissolve decreases as the number decreases. When they float in water they attach to organic material and thus end up in the food chain. The PCB content in food for birds and seals is so high that some scientists fear that it has a negative effect on reproduction.

In the beginning of the nineties, the vast majority of the PCB settled in the sludge of the Westerschelde was carried by the Scheldt from Belgium. So was it that in 1991 alone four kilos of PCB came across the border, while about another 70 grams was added to that from the Ghent-Terneuzen Canal. (This doesn't seems like much, but PCB are already harmful in very small quantities). Dutch sources also added several dozen grams. The concentrations in organic material decrease from east to west because the ocean carries in material with a lower concentration and this marine material mixes with the fluviatile.

Since PCB accumulate in organisms, these are used for ascertaining the situation. Mussels are often used for this type of monitoring by organisms – called bio-monitoring – because these animals are easy to collect and are distributed over a large area.

In the figure, one can be follow the development of PCB content in mussels from the Westerschelde. The seven PCB which are grouped together are PCB 28, 52, 101, 118, 138, 153 and 180. The green and red lines indicate the objectives of the Westerschelde Policy Plan, which were laid down in 1991 by the Westerschelde Administrative Consultation. According to this objective, PCB content in bottom dwellers should already have been reduced by 80 percent in 1995 and by 90 percent, at minimum, in 2001. The figure shows that it may be true that there is a reduction of the seven PCB together, but that the objective has not been met.



PCB-content in mussels from the Westerschelde, 1990-2000 (Source: Scheldt Information Centre/RIKZ)

PAH

Unlike PCB, polycyclic aromatic hydrocarbons (PAH) do occur in nature, albeit in low concentrations. For example, they are created by forest fires. The great majority of PAH end up in the environment as a result of incomplete combustion. These chemical compounds also occur in tar products and creosoted wood. Just like PCB, they attach to organic material in water. In animals they accumulate in fatty tissue.

Fluoranthene, which does not dissolve well in water as a result of its high molecular weight, belongs to the group of the heavy PAH. Some PAH cause cancer.

Because PAH are usually attached to organic material and organic material in turn may constitute a considerable proportion of sludge, PAH are found primarily in areas where sludge settles. The concentrations in the Westerschelde decrease from east to west because the ocean carries in material with a lower concentration of PAH and this marine material mixes with the fluviatile.

The Scheldt and the Ghent-Terneuzen Canal are again the important suppliers of PAH, but industrial companies around Vlissingen have also contributed considerably to the pollution. The amount of fluoranthene entering the environment diminished considerably in the eighties and nineties, but the concentration is still a few times higher than that of the Rhine. The target value has not yet been attained.

Cadmium

Cadmium is one of the inorganic micro-contaminants, along with other heavy metals such as copper, zinc, lead, arsenic, mercury, nickel, chromium and cobalt. These metals naturally occur in the Scheldt water because they erode from rock formations found in the Scheldt watershed. However, natural conditions involve very small amounts and are actually essential to numerous organisms at such low concentrations, though this does not always follow for all trace metals. Copper is essential to a high extent, but cadmium is not. All trace metals become poisonous in high concentrations and they accumulate in the organs of animals.

The amount of cadmium in the Scheldt estuary is mainly produced by a large number of point sources, such as the metal industry and ore-processing companies. Included in diffuse sources are batteries, paint and plastic in which cadmium is used as a pigment.

Trace metals also attach to sludge and organic material, causing them to accumulate in areas where sludge settles. The concentrations in the Westerschelde decrease from east to west because the ocean carries in material with a lower concentration of cadmium and this marine material mixes with the fluviatile. The amount of cadmium carried from Belgium is many times larger than what is added to it on Dutch soil. The amount carried across the border at Zandvliet is 95 percent of the concentration measured in the Scheldt water. Still, the contribution of the Scheldt to the pollution of the North Sea is less than that of Meuse and Rhine. The target values for cadmium as well as for the other heavy metals have not been attained, with the exception of arsenic.

Nitrogen

Nitrogen is a nutrient that, just like phosphorus and carbon, is a natural and fundamental cornerstone for cells of plants and animals. Nitrogen is found in the surface water in different forms: ammonia, nitrite, nitrate, as organic nitrogen compound in solution and as nitrogen per se. If the water does not contain sufficient nitrogen or phosphorus, the formation of plant material, especially the formation of algae, stagnates.

Conversely, a surplus of nutrients causes excessive growth of algae, which may lead to the feared “green soup”. This though is not a problem in the Westerschelde, because the water – as a consequence of the large amount of sediment it carries – is so murky that growth of algae stagnates due to a lack of sunlight.

Nitrogen ends up in the Westerschelde because of the organic waste nature itself produces and from the use of fertilisers in agriculture, which end up in the surface water after being flushed out. About 80 percent of the nitrogen in the surface water is found in inorganic solution (as nitrate, nitrite or ammonia).

In 1991, the Scheldt carried about 35,000 tonnes of nitrogen at Rupelmonde. A little less than 25,000 tonnes was added to this between Rupelmonde and Vlissingen. Of the total amount of nitrogen in the river, four-fifth flowed into the North Sea. This 47,000-tonne quantity was nearly as much as what was carried by the Eems or the Theems, but considerably less than the contributions of the Rhine and Meuse.

In the past few years the concentration of nitrogen has steadily decreased. To a great extent that reduction is due to water purification installations in the Dutch section of the estuary that have been expanded by using technology that can also remove nitrogen and phosphate.

Paradox of the Scheldt estuary

At any rate, the amount of nitrogen at the Belgian-Dutch border has been increasing again since 1996. Strangely enough, that growth is attributed to the improvement of the water quality and the associated rise in the concentration of oxygen. More oxygen is fatal to the denitrification process, where nitrogen, principally nitrate, is converted into nitrogen gas (and laughing gas, to a lesser extent). This process only works in very oxygen-poor conditions. The reasons behind what has become known as the paradox of the Scheldt estuary, ‘cleaner, more oxygenated water and yet holding more nitrogen’, are still not clear.

The objectives for industrial discharges for nitrogen have been met, but those for phosphorus have not. Both the Westerschelde and the Lower Zeeschelde show phosphorus concentration which are one to two orders of magnitude higher than the natural concentrations expected. In the fresh-water part of the estuary, phosphorus precipitates as an effect of physio-chemical processes and redissolves as the conditions allow. Accumulation of phosphorus in bottom sediment would at a certain moment be able to cause mass liberation.

Carbon

Surprisingly, the water of the Scheldt estuary is one of the large CO_2 discharge systems in Europe. The emissions from water into the air may vary from 50 to 350 tonnes (!) of carbon per day. That maximum is about on par with the emission of the heavy industrial areas into the atmosphere.

For the greater part – about 200,000 tonnes per year – carbon ends up in the Scheldt in the form of organic compounds in non-purified communal waste water. During the cold part of the year that is about 90 percent of the total. The remaining part is created during that time of the year by dead embankment and salt-marsh vegetation and by plankton photosynthesis. During the summer periods of algae growth, the latter source produces a share of around 50 percent. Remarkably, research by Billen (1993) and Van Damme (1999) shows that only a fraction of the total amount of carbon reaches the ocean. The reason for this is that the Zeeschelde and the Westerschelde behave like an enormous bio-reactor. The Scheldt water passes through this for a relatively long period because it continues to flow back and forth due to the tidal effect. This allows bacteriological processes which break down organic material to gain a great deal of momentum. One of the break-down products is CO_2, which is released into the air and which contributes considerably to the green house effect.

Earth metals

In addition to “familiar” substances, new materials, whose effect we know relatively little of, end up in the environment as a result of modern production technology.

This applies, for example, to the rare earth metals scandium (Sc), lanthanum (La), cerium (Ce), neodynium (Nd), samarium (Sm), europium (Eu), terbium (Tb) ytterbium (Yb) and lutetium (Lu). They are found in the same concentrations as lead, copper, cadmium and mercury and just because of that they warrant as much attention in the future policy as the “familiar” substances.

Discharge from diffuse sources

Now that discharge from industry and households are being remediated or at least being tackled, there remains the task of reducing discharge from diffuse sources. This includes atmospheric deposit, release of substances from building materials, traffic and transportation (including shipping), agriculture and contaminated water bottoms.

In agriculture, the main issue is pesticides, such as insecticides and fungicides which contain more than a hundred active substances, of which only some are measured. In the Netherlands, the General Administrative Measure for outdoor cultivation took effect in 2000 – a stimulus to reduce this type of pollution.

Plans and intentions for the Scheldt

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Delta ecosystem vision

"Delta Ecosystem Vision", the information document published by the Ministry of Agriculture, Nature Management and Fisheries at the end of 1994, states that the eastern part of the Westerschelde is the heaviest polluted tidal area in the Netherlands. The cadmium concentration is especially very high, but also PCB, PAH and "organotin" compounds are found in far too high concentrations. Furthermore, the Ecosystem Vision points out that, "The Scheldt River system is permanently out of balance. The river system naturally tries to find a balance in the process of sludge deposit and erosion. However, dredging and dumping sand makes that very complicated." The channels have been deepened four to seven metres lower than their natural depth. Because the sludge taken out by dredging is dumped back in parallel channels, sedimentation in the Land van Saeftinge and on the shoals of Valkenisse develops very quickly, while salt marshes and mud flats are actually reduced at other locations.

The Ecosystem Vision also concludes that it is precisely the estuarian nature of the Dutch delta that is the most valuable component and that open ocean inlets are of great importance for the biodiversity, because many species of fish, crustaceans and other aquatic animals are found there. The estuary is the source of food, breeding place and the area to raise the young offspring. Furthermore, the salt tidal area is the temporary abode for migratory fish. The tidal areas, rich in food, also serve as important foraging areas for birds on their migratory routes and for other birds as the place to spend the winter.

East-West study

The final report of the East-West project, which was published at about the same time, also pointed out the importance of the open connection between river and ocean. This study of physical and biological process in the eastern part of the Westerschelde concluded that the estuary is filled in because the tide storage (the amount of water a river can hold) is reduced. That quantity has dropped over the years as a result of dike construction and raising industrial areas and is still dropping due to sedimentation.

As a result of "tinkering" with the shipping channel, the natural dynamics, so characteristic for an estuary, have decreased. Natural alternation of function between the main and parallel channels will no longer be likely to occur. The main channel can certainly move less freely and is even fixed where the river flows along dikes. By fixation of the shipping channel, shoals can also increase in size. On the other hand, mud flats in the outer bends of channels are more sensitive to erosion now that more water is flowing through the dredged channels, which can also flow faster.

The East-West study states that the estuarian nature of the Westerschelde is being threatened. The report lists the following as proof of this: decrease in intertidal zone surface area, the rare occurrence of the salt-marsh formation phenomenon and reduction of sludge-rich, low-dynamics areas in the eastern part of the Westerschelde. Everything considered, the report predicts dynamics will slow down and there will be a more rigid, less complete estuary.

Reports

In order to turn that tide, different reports were published over the years which all propagate the unusual characteristics of the Scheldt estuary. These include the "Long-term Scheldt Vision", the "Westerschelde Nature Compensation Program", the "Westerschelde Policy Plan", the "Westerschelde Promotion Program", while the updated "Sigma Plan" offers more room for the natural dynamics of the river.

Long-term Scheldt Estuary Vision

The Technical Scheldt Commission laid down the "Long-term Vision" on January 18, 2001. This vision regards the estuary as one system in which all components are related. The water does not allow itself to be bound by national or provincial borders, nor does it concern itself with classifications in functions or areas. The estuary is above all an area where river and ocean meet.

Three functions are central in the Long-term Vision: safety from floods, access to the Scheldt harbours and naturalness of the physical and ecological system. Even though these functions are separately focused on in the vision, they are continually related to one another and their connection is emphasised wherever possible.

The document consists of three parts: a target image for 2030, some development sketches for 2010 and a short-term situation sketch. The target image for 2030 is that the estuary will be a healthy and multi-functional estuarian water system, used in a durable manner for human needs. The essence is expressed in five characteristics.

1. Maintaining the physical system characteristics of the estuary is the basic assumption for management and policy.
2. Maximum safety is an important pre-condition to exist for both countries.
3. The Scheldt harbours, as the work horse of prosperity, shall have optimal access.
4. The estuarian ecosystem shall be healthy and dynamic.
5. The Netherlands and Flanders shall co-operate politically and operationally.

The physical system, with its channels, shoals, mud flats, salt marshes, embankments, fresh and salt water is considered to be the "bearer" of all functions. The estuary area will have to be open and natural. The multi-channel system in the Westerschelde will have to be maintained: main and parallel channels with shoals and shallow water areas interspersed will continue to be the Westerschelde characteristic. The Zeeeschelde will continue to be a river system with a meandering nature. And there will be different areas throughout the entire estuary: deep, shallow, salt, brackish, fresh, open water, nature-friendly banks.

Four development sketches

Choices for the medium-long term have not been made yet. The Long-term Vision does indicated what the possibilities are and within what limits the measures will be sought. To do this, four development sketches have been drawn up, each with its own character. Development sketch A assumes that the present policy does not change essentially. This means that the navigation channels will not be deepened any further, but that something extra will be done to benefit nature. In development sketch B the study option from the treaty between the Netherlands and Flanders on access to the Scheldt harbours will be implemented. This means deepening the navigation channels by two feet. The damage to nature will be compensated for over and above the measures provided for in development sketch A.

The characteristic of development sketch C is that intervention will take place in the estuary, but in relatively small steps. That way the lessons from the previous period can be used in each subsequent step. This development sketch pursues an as large as possible deepening of the navigation channels in periodic steps of, for example, five years. The depth that is feasible depends on the effects on morphology, safety and nature. This is counterbalanced by a hefty investment program to compensate for the damages inflicted on nature. Development sketch D differs from C in the fact that drastic interventions are also implemented. Thus the navigation channels are deepened to, for example, 14 metres, independent from the tide, all at once. Large investments in nature will also be made in that case all at once. The advantage of this approach is that the situation of the access to the Scheldt harbours will become clear quickly. However, they also entail big risks. The effects on safety and naturalness are not actually well known.

Therefore, the Long-term Vision also affirms that a combined program for monitoring and research must be set up as soon as possible. Eventually, combined research will be carried out in all important policy areas. Thus, this applies to morphology, ecology, safety, shipping and the port economy. Such a combined research program will continue to produce more data, making it possible to manage the estuary with increasingly more knowledge of what’s going on.

The ball is now in the park of the Flanders and Netherlands governments to stipulate a viewpoint.

Westerschelde nature compensation program

In the treaty signed by Flanders and the Netherlands in 1995 on enlarging the navigation channel in the Westerschelde, it was agreed that the natural values which were lost would be compensated for. The Netherlands handles implementation, Flanders will assume a considerable share of the costs.

The first plans assumed enlarging the estuary by returning a few polders to the ocean and the Westerschelde. However, this met with such fierce resistance from the Zeeland population that it was abandoned.

How the implementation would proceed was arranged at a management meeting in February 1998 (only the Borssele municipality did not sign). The compensation measures are subdivided into three categories: inside the dikes, outside the dikes and creek recovery/quality impulse to the Nature Policy Plan.

This section not only discusses the projects outside the dike. It was stated in the agreement that these must be completed as much as possible within five years. The five projects involved are: protection of the Zuidgors (immediately east of Ellewoutsdijk) and the adjacent Baarland, the ferry harbours of Kruiningen and Perkpolder and two nesting areas at Terneuzen and Hansweert.

Protection of the Zuidgors

The Zuidgors has been suffering from erosion over the past few years which is indirectly caused by high current speeds, especially at high tide. As a result of this, the mud flat between the Everingen channel and the Zuidgors is being reduced in height and width. A steep salt marsh cliff has gradually been created, a few metres of which wash away each year.

Rijkswaterstaat, the province of Zeeland and the Zeeuwse Eilanden water authority, as well as the Nature Monument Association participated in seeking out a solution. The researchers eventually chose construction of a levee from the various alternatives, even though there were some disadvantages associated with this. For example, the report "Weighing and Deliberating" from the Ministry of Transportation and Public Works (from 2001) stated that the dam would be buiilt at the expense of the natural state of and the dynamics in the protected area beyond the dam. The measure also requires drastic intervention (including installing channel wall protection), which results in high installation and maintenance costs.

Exactly those disadvantages caused Rijkswaterstaat in the summer of 2001 to decide not to construct the dam. The high costs did not balance the benefits for nature and the environment. It has now been decided to do nothing at all.

The ferry harbours of Kruiningen and Perkpolder

When the tunnel under the Westerschelde is put into operation in 2005, the ferry service between Kruiningen and Perkpolder will stop operating. The harbours where the ferries are now still mooring can then undergo a change of use. Turning them into nature reserves is one possibility, but not the only one. The chance of doing this is best at the Kruiningen harbour. 10 to 15 hectare of mud flats and salt marshes could be created at that location, to which another quantity of the same amount could be added by also including the toll plaza in the plans. For the Perkpolder harbour there are plans other than turning it into a nature reserve. In case that choice is still selected, Rijkswaterstaat made a layout sketch of a 25-hectare mud-flat and salt-marsh area.

Nesting areas near Terneuzen and Hansweert

The plan for expanding the terrain near the Terneuzen locks complex, where a colony of terns is nesting, has been put on the back burner now that the colony has strongly declined in the past few years. Studies on the causes, carried out by the Federal Coast and Sea Department, provisionally attribute the deterioration to hexabromocyclododecane (HBCD) and tributyl tin (TBT). These flame retardants occur in high concentrations at (the mouth of) the Ghent-Terneuzen Canal and this is precisely the area where the terns feed. While awaiting additional studies on the high death-rate among young terns, implementation of this nature compensation plan has come to a halt.

At Hansweert the plans are still in a provisional phase. Three alternatives have been elaborated for a sludge depot which was set up around 1990, when the Canal section through Zuid Beveland was adapted. These vary from doing nothing to digging a tidal creek, creating a connection with the Westerschelde.

The updated Sigma Plan

The intention of the Flemish Sigma Plan dating from 1977 is to protect the Zeeschelde basin from storm floods from the North Sea. It comprises three components:

- raising and reinforcing the water barriers (512 km);
- creating controlled flood areas (GOGs) and compartmentalising dikes;
- building a storm flood barrier.

Raising and reinforcing the dikes and water barriers are planned as follows:

- up to level +11.00 m TAW at the Zeeschelde from the Dutch border to Oosterweel (TAW stands for Tweede Algemene Waterpassing [Dutch abbreviation of the Second General Water Standard]; NAP = 3D 2.33 m = TAW);
- up to level +8.35 m TAW at the Zeeschelde from Oosterweel to Temse;
- up to level +8.00 m TAW at the Zeeschelde from Temse to = Gentbrugge and beyond in the Durme, Rupel, Nete, Dijle and Zenne rivers.

A controlled flood area is an area with an extensive storage capacity and where the river dikes have been kept lower on purpose. Spilling can withdraw a quantity of water from a flood tide wave, lowering the height of the storm flood.

The storm flood barrier, planned at Oosterweel, must be able to resist a storm flood which would raise the water to almost nine metres TAW at Antwerp. The cost price of the construction is estimated at about 40 billion BEF (1982 price level).

Other insights

Around the millennium change, the question arose of whether the Sigma Plan still met expectations and whether the basic assumptions of the seventies, such as those on the water levels in the Zeeschelde, were still the same. According to the new insights, the safety of the Zeeschelde basin can also be enhanced in a different manner. Instead of the storm flood barrier, additional GOGs can be built, especially in the upstream part of the estuary, if necessary in combination with two smaller and thus cheaper storm flood barriers near Lier and Mechelen. With these measures, the Zeeschelde basin gains a safety level comparable to that of the Westerschelde.

Because a rise in sea level of 60 centimetres must further be taken into account during the next hundred years and because the storm frequency has increased in the past few decades, the Sigma Plan was updated in 2001. The emphasis in this plan was put on extending the number of GOGs – especially along the Durme tributary – with no storm flood barrier. Studies have shown that the advantages of these storm flood barriers are minor in comparison to the enormously high costs of building and maintaining them. Raising the dikes more is also no solution because the dikes would become unrealistically high in that case. Furthermore, higher dikes only defer the problem, because a storm flood will enter the interior more deeply due to the funnel-shaped route and can cause even more damage there.

The GOGs can be given an extra function by not letting them only flood at extremely high water levels, but also submitting them to the daily effect of the tide. The Sigma Plan uses the term of areas with GGGs (controlled reduced tide) in these cases. This way they not only provide safety, but are part of the estuary at the same time.

New safety approach

In addition, the updated Sigma Plan uses a new safety approach. As starting point it uses the principle that water control plans must be designed on the basis of protection from damage instead of protection from high water levels.

The Life-project Mars

Mars stands for “Marsh Amelioration along the River Scheldt” and is a European project for restoring the mud flats and salt marshes. It includes four projects, three in Flanders and one in the Netherlands.

The intention at Temse is to keep the five-hectare fresh water marsh Het Kijkverdriet from growing over. This could be done by digging away the large amount of sludge settled on the bottom, allowing water to run through

2. Nieuwe veiligheidsbenadering

kans groter

gevolg kleiner

risico = kans * gevolg

- kans : overstroming en/of dijkbreuk
- gevolg : schade uitgedrukt in BEF

New safety approach in the Flemish Sigma plan.

2. Nieuwe veiligheidsbenadering

kans klein

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the salt marsh more frequently and giving "spindotters" *(Caltha palustris araneosa)* a chance to thrive again. Bottom studies of the ground to be dug away have demonstrated severe contamination of cadmium, chromium and arsenic. This makes it impossible to reuse the soil, so that the only remaining options are dumping or processing it. The high costs associated with this have led to postponement.

The same is true for the Lippenbroek project at Hamme. At this location, a ten-hectare polder was to be dug down and set up as a controlled reduced tidal zone (GGG) to see if the fresh water marsh vegetation would also develop if the Scheldt were to flood the polder at high tide. Since the soil of this agricultural polder also appeared to be contaminated, implementation was halted while awaiting a study on what must be done with the soil.

The third Flemish project is not going much better than the first two. The Groen Meirsch salt marsh at Zele, raised to be used as a ship yard with ad joining breaker's yard, will be dug down to its natural height, but the soil and groundwater appeared to be contaminated so seriously here that it was decided to postpone the project, certainly after the costs of remediation had been estimated at 60 million BEF.

Only the Dutch project: recovery of the tidal creek in the Kaloot, a minuscule remnant of a large nature reserve near Borssele, was indeed implemented. The silted up access channel was dredged in 1997, the dunes along the west side were expanded and a screen to prevent sand from blowing around was installed.

Westerschelde Policy Plan

The main objective of the Dutch "Westerschelde Policy Plan" from 1991 is stated as follows: "Creation of such a situation, with preservation and consideration of the area's shipping function and its development potential (with the associated seaport and industrial activities), that nature function can be maintained and restored and, furthermore, that potential nature values can be developed. That must also lead to a good starting position for development of fishery and recreational functions. The importance of water barriers must be safeguarded in this."

Action plan

The policy plan must be accompanied by an action plan for the shipping and seaport activity, ecology and water management, recreation, fisheries, water barriers and other functions.

The objective for shipping is that this must be made safe. That means that recreational navigation in and along the main navigation channel and busy parallel routes must remain limited. Separation of types of traffic is the basic starting point. Furthermore, effective supervision is necessary and sufficient and easy-to-use facilities have to be set up for chemical waste and used oil. The port facilities will have to be adapted to the technical and economic changes of shipping.

In the area of bottom and water quality, preservation of the fresh-salt transition and the morphological dynamics are two of the objectives. That is why the hatchery function in the shallow water areas and the bird function of intertidal zones and salt marshes must also be preserved, as well as the vegetation of salt marshes and the communities of the tidal creek areas.

Recreation can be expanded in some areas, but in that case it must be ensured that the nature values are not being affected.

The most important objective of the fisheries is restoring favourable conditions for quality and quantity of the catch and thus of coastal water fishing as a business branch. This makes it necessary to improve the water quality and select the locations and manner of dumping dredge sand in such a way that, to as great an extent as possible, negative consequences for the fish stock fail to occur.

In relation to the combined interests of water barrier, recreation and nature, the eroding sandy coasts in the estuary area must be restored as much as possible by sand supplementation. The erosion along the salt marshes that is the consequence of the dredging process can be prevented by setting up (pre-) embankment protection and depositing rubble.

Embankment protection materials must be geared to maintaining flora and fauna in the intertidal zones as much as possible.

Other functions

"Other functions" in the Westerschelde Policy Plan include, among others, generating wind energy and extracting sand. In regard to the former the policy plan notes that there is no place for wind turbines in the water, on land that has become dry or in intertidal zones and that the important bird functions of the area, the importance of the water barriers and possible interference with navigation and with radar and other positioning systems must be taken into account when placing windmills.

The policy for commercial sand extraction must be geared to the morphological equilibrium in the sand balance and may in principle only be carried out below the NAP = 5.00-metre level.

Evaluations

Meanwhile, whether the objectives are keeping up with the developments has been examined twice. In the most recent evaluation, in 1998, the conclusion was that the developments are, in broad outlines, in synch with the policy plan. Only the items of shipping, water and soil quality and recreation demand additional attention.

In fact, shipping may pose a hazard to residents along the banks of the Westerschelde, especially if ocean vessels are transporting hazardous substances (ammonia).

In regard to the soil and water quality the evaluation report states that the concentration of oxygen complies with the national standards more all the time, but that the concentration in the eastern section is too low in the summer. The reduction objectives for (in)organic micro-contaminants have been met, but industrial emission of phosphate not yet. The report designates the concentrations of chromium, nickel and PCB worrisome. All in all, the quality set for the soil for 1995 was not achieved.

The authors of the evaluation report are worried about recreation because, "A considerable percentage of those who participate in recreation access areas which are not considered appropriate for recreational joint-use."

The evaluation concludes with the observation that only a few actions relate specifically to recent developments and large-scale activities. Therefore, future revision of the Policy Plan and the action plan are predicted.

The Scheldt Action Plan

One of the tasks which the International Commission for the Protection of the Scheldt was given when it was created in 1994 was "Setting up (É)target objectives and an Action Program especially comprising actions focused on all types of point sources and diffuse sources of contamination, in order to preserve and improve water quality and, more generally, the ecosystem."

This action plan was published four years later. It is divided in three periods: a short term (until the end of 2003), a medium length term (until 2013) and a long term (through 2025). After each period the plan will be re-adjusted in order to capitalise on new developments and insights. The Scheldt Action Plan takes into account both the programs that were or are carried out by each party to the treaty, and the European legislation and directives which the parties to the treaty have converted into their internal legislation. The OSPAR treaty to protect the marine environment in the north-eastern Atlantic Ocean is also a starting point.

Scheldt water quality databank

The Scheldt Action Plan gives absolute priority to improvement of the oxygen system by attacking classic pollution, being oxygen-binding compounds and nutrients. A homogeneous measuring network has been organised to evaluate the water quality, eliminating the differences between countries. The data are collected in the Scheldt Water Quality databank.

In order to gain insight into discharge into the Scheldt and its tributaries, emissions from the big industrial installations are mapped and permits compared to and tested against the European regulations. Thermal contamination also is part of the inventory.

In regard to discharge of urban waste water, the Commission is checking which standards are used by the individual countries, which purification procedures are applied and whether the European directive about this matter (91/271/EEG) has already found acceptance.

The Commission intends to gain insight into the consequences of diffuse contamination by making a synthesis of the legislation in the different countries and checking how far each country has progressed with implementation of remediation of housing units which are not connected to the sewerage, with reduction of contamination by substances from agriculture due to flushing and run-off, with remediation of recreation areas, with reduction of pollution by commercial shipping and pleasure boating and with application of the best environmental practices.

Another important objective is prevention of disastrous contamination comparable to the Sandoz disaster in Basel in 1986, when tonnes of chemicals ended up in the Rhine. In order to protect the Scheldt from such a disaster, all possible sources of disastrous contamination are inventoried and all measures which can be taken to prevent and combat such a disaster, should it occur in spite of the measures, are summed up.

Short-term Action Plan

The short-term action plan consists of more than taking inventory. It also comprises a few ecological recovery programs and measures to limit discharge. As far as the latter is concerned: France will stimulate internal inspection of industrial discharge; Wallonia will replace the Baudour electricity plant with a gas turbine; Flanders will install city sewerage at an accelerated pace; the Brussels Capital Province will insist on meeting the (voluntary) agreements with the industrial sectors on application of the best available techniques; and the Netherlands will make more sewage purification plants suitable for removal of nitrogen and phosphorus.

As far as ecological recovery of rivers is concerned: France is going to develop a program for ecological maintenance of rivers; Wallonia is setting up a few nature parks including Les Haut Pays and Scarpe-Escaut; the Flemish Province will elaborate an ecosystem vision for a few river and brook valleys; the Brussels Capital Province will continue its policy for separation of waste water and clean water; and the Netherlands will implement the Westerschelde Nature compensation program.

Cultural differences

It has become clear in the seven years of ICBS existence that the co-operation is not always smooth. Part of this problem can be blamed on the complicated political administration structure within Belgium, but in addition to that co-operation is made more difficult due to cultural differences. While Dutch people tend to approach business matters in a direct manner, their southern neighbours prefer a meandering approach.

In the “Work Plan and Strategy for Realisation of the Scheldt Action Plan I, 2000-2004”, which was published by the ICBS workgroups 1 and 2 Secretariat for National Pre-consultation, it is even stated that, “In the Scheldt and ICBS case, the cultural differences contribute to or are the most important cause of ‘endless debates’ between France, Wallonia, Brussels, Flanders and the Netherlands related to water management problems. Whereas in France and Belgium strong hierarchical relations influence the decision making and people cling to their own ideas and comply with the social rules, horizontal power relations apply in the Netherlands while strict rules of behaviour are absent. These differences not only exist between countries, but also between organisations. Interwoven in this are also the differences in manners between men and women and between different age groups. Thus the section ends with the recommendation that water managers and policy makers within the ICBS should pay more attention to differences in culture and decision-making.”

A clean Scheldt also demands good manners.

Current and new research projects

14

A short description of research which is still in implementation and is mainly in the conclusion phase, as well as research which was begun in 2000.

Anthropogenic organohalogens (Substance study)

The presence of about half of the organohalogens in surface water can be explained by natural processes. The other half is anthropogenic (industry, households, purification processes). In this substance study the load of the surface water is examined, as well as which substances are involved and what the risk substances are, for each category. Possible follow-up actions are also discussed.

Detergent additives (Substance study)

Complexing agents (EDTA, NTA, DTPA) and alkylphenol polyethoxylates can be found under the ingredients of laundry and cleaning detergents. These substances and their decomposition products end up in the surface water in large quantities. The complexing agents themselves may be harmful to the water environment, but they are also suspected of causing heavy metals bonded to sludge being redissolved in the water. Alkylphenol polyethoxylates can break down quickly into alkyl phenoles, which cause a pseudo-oestrogen effect. Little is known about the quantities and concentrations in surface water. The substance study makes estimates of the extent of the use of these additives, of the consequences to the aquatic environment and of possible risks for drinking water preparation.

Origin of AMPA

The presence of aminomethylphosphonic acid (AMPA) has been a source of concern to the water companies since 1994/1995. The reason for this concern is that the substance is known as the decomposition product of pesticide glyphosate and therefore, despite its low toxicity, must be used in accordance with the pesticide standards of 0.1 µg/l. The AMPA concentrations found in the surface water cannot be explained just by the use of pesticides. It may be true that the 1996 RIWA studies demonstrated that AMPA is also created by phosphonates (laundry detergents, cooling water additives), but the contribution from these sources still appears too small to be able to explain the concentrations (see also the discussion on cooling water additives in “published reports”). In 2000 project-context brainstorm sessions were held with a glyphosate producer and various chemical organisations about possible other compounds which could be the precursors for AMPA. The suggestions made had to be examined later.

Application of new criteria

A project was concluded in 1999 which had developed a schedule to make a selection of priority substances by means of a number of criteria. A project in which these criteria will be applied to all substances included in the “Inventory and toxicological evaluation – 1999 revision” report is planned for 2001. As preparation, an inventory will be made in 2000 on which substances were found in the period up to 1999.

Cryptosporidium parvum

In 1998, a follow-up study was initiated on parasitic protozoa in the Rhine and Meuse and near intake points of water companies. In addition to the usual quantity determination, the number of viable and pathogenic-to-human oöcysts *(Cryptosporidium parvum)* can be determined. Since a need arose for results that could be compared with each other, it was decided to also take measurements in the Rhine and to also take a few samples in the summer in addition to in the winter.

Toxins of cyanobacteria

Some cyanobacteria (blue algae) can produce toxins under certain conditions. In the last few years it has become clear that these toxins may pose a serious risk to public health. They are being related to liver diseases and liver cancer. In 1998, six water companies tried via literature studies to estimate to what extent cyanobacteria are removed during purification of surface water into drinking water. Systematic studies on the presence of such toxins have not been carried out, however. A project was initiated in 2000 in RIWA context to take measurements at drinking water company intake points for toxins which are produced by cyanobacteria.

Climate change and water supply of the Meuse

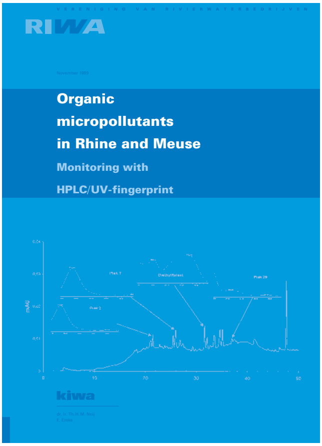
In the project on the impact of the hydrological intervention in the Meuse (see the chapter "Published reports"), it was recommended, among other things, to further investigate the effects on climate changes on the Meuse discharge. Such studies are advisable particularly in the case of the Meuse because the chance of too low a discharge in this river is the greatest in the summer months, when the demand for water actually increases. The average Meuse discharge in the Netherlands is about one tenth of that of the Rhine, and the Meuse discharge also shows much more distinct fluctuations. For a few years RIZA has already been examining what the effects of climate changes on the discharge of the large rivers will be, by means of hydrological models. Such models can be focused on the various aspects or functions of a river, such as safety, inland navigation, drinking water provision, nature or agriculture. It was decided in 2000 to support, in RIWA context, the development of a model which could be used to predict the consequences of climate change on drinking water extraction in the Meuse watershed. The purpose is mapping bottlenecks (where does water shortage occur when?), of the coherence in extraction upstream and downstream, of relations with other extractions and of solutions. In this manner, climate changes are expected to be anticipated in time.

Published reports

15

The majority of the reports described below were published in 1999 and 2000. A few reports were not published until 2001, but are included in this annual report because they had mostly been concluded in 2000.

HPLC/UV-fingerprint (1999)



VERENIGING VAN RIVIERWATERBEDRIJVEN

RIWA

November 1999

Organic
micropollutants
in Rhine and Meuse
Monitoring with
HPLC/UV-fingerprint

kiwa

dr. ir. Th.H.M. Noij
E. Emke

The water in the Rhine and Meuse is frequently examined for a large number of parameters. However, because the surface water contains a great many more substances than can be measured, there is a lot of interest in biological monitoring systems. Yet it will remain necessary to supplement biological measurements with analytical measurements that can provide a picture of the water quality, preferably as simply and as cheaply as possible. Therefore, a method was developed which makes a broad range of organic substances visible without demonstrating each substance individually, the so-called "fingerprint".

In this method, the organic substances are isolated from a water sample and separated by means of HPLC (High Performance Liquid Chromatography) in order of polarity. The substances are eventually detected by UV absorption. With this method, call "HPLCX/UV fingerprint" for short, polar and moderately polar organic micro-contaminations are measured in concentrations starting at about 0.1 µg/l.

The quality of Rhine and Meuse water was measured by means of the HPLC/UV finger print technique. Monthly samples from the Rhine at Lobith and the Meuse at Eijsden from March 1997 to February 1998 were examined. Both global water quality and the presence of individual contaminations were studied. The pollution in the Rhine appears to be more constant and about a factor of two higher than that in the Meuse. The water quality of the Meuse varies more widely than that of the Rhine and is mostly determined by a small number of compounds which occur incidentally in high concentrations. The Rhine is polluted the most during the fall and winter, the Meuse especially in the summer and the fall.

Pesticides were usually demonstrated to be present in concentrations corresponding to those from the regular measuring program. Pesticides not included in this program were also detected, such as carbendazim, monuron and dimethylchloride. Including these substances in the regular measuring program is also recommended. It is further recommended to identify unknown substances, which are measured frequently and in high concentration by means of the follow-up study and to assess them. By using this method it appears quite possible to demonstrate incidental contaminations and retrace them if necessary. In addition to that, the method is very suitable for selecting unknown substances for more detailed identification study. The report was published in both Dutch and English versions.

Mutagenity in Rhine and Meuse in 1998 (1999)


VERENIGING VAN RIVIERWATERBEDRIJVEN
RIWA

November 1999

Mutageniteit in Rijn en Maas
in 1998

kiwa

H.R. Veenendaal
dr. J. van Genderen

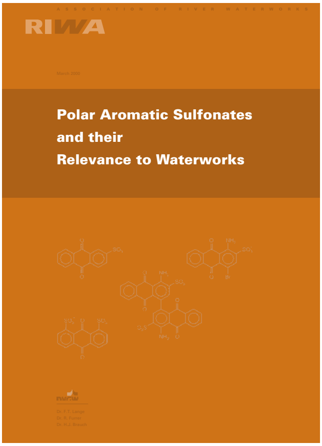
Amestesten
in revertanten per liter met de
pH7 en pH2
fracties getest met en zonder
S9-mix

Since 1992, the mutagenity of the Rhine and Meuse water was studied every other year by means of the Ames test. Seven water samples from the Rhine at Lobith were examined in 1998, the last one in January 1999. Six water samples from the Meuse in Eijsden were examined.

Mutagenic activity was demonstrated in all seven samples of Rhine water. The highest activity was encountered in the samples taken during the winter months, especially in the fractions which were tested with the S9 mix (liver homogenates of rats). No activity or only marginal activity was detected in the Meuse water. The drop in mutagenic activity, which has been found in both Rhine and Meuse water for a few years already, continues. The suspicion that this is related to the drop in concentration of certain groups of substances will still have to be confirmed by further chemical analysis studies in combination with the Ames tests.

The report also discussed a study from 1997 and 1998 which focused on the relation between the measured mutagenity and materials with a certain lipophilism. There was, namely, a suspicion that compounds in strong hydrophilic and strong lipophilic fractions could not pass the cell wall or would have difficulty in passing it, with the result that no mutagenic effect or a reduced effect occurs. The study, carried out with the use of samples of severely contaminated surface water, demonstrated that the mutagenity was always present in lipophilic material with a log Kow value between 1 and 3, with the maximum at 1.8. Below or above these values no mutagenic effects were observed. The report is available in Dutch.

Polar Aromatic Sulphonates and their Relevance to Waterworks (Substance study) (2000)


ASSOCIATION OF RIVER WATERWORKS
RIWA
March 2000
Polar Aromatic Sulfonates
and their
Relevance to Waterworks
Dr. F.T. Lange
Dr. R. Furrer
Dr. H.J. Brauch

Aromatic sulphonates belong to the group of chemicals which have been produced on an industrial scale longer than any others. They have been used since the end of the past century as a versatile semi-finished product (for colouring agents, for example) and nowadays also as fluorescent whiteners in laundry detergents, as dispersion agents in various industrial processes, as softeners in the concrete industry and as synthetic tanning agents. This study involves sulphonates which are relevant to the drinking water preparation due to production and consumption quantities, solubility in water and poor decomposition. They also must have been encountered in the aquatic environment more than once, at minimum.

Except for sulphonated active substances in laundry detergents and cleaning agents, no measuring results of individual aromatic sulphonates in water had been made until the 90s. Only in the past few years were they measured in surface water and drinking water, but the analysis methods have not yet been standardised. The substances were demonstrated (in concentrations up to 80 µg/l) in water flowing from dumps in Switzerland and Germany. 26 different compounds have been measured so far in treated waste water. The surface water measurements available involve only creek and river water. Especially naphtalenesulphonates appear to occur in the Rhine, Elbe and

Danube. Concentrations from 10 ng/l to 10 µg/l are normal, but in the Elbe an incidental concentration of 100 µg/l was measured. In drinking water, only naphtalene sulphonates (di and trisulphonates) were measured in very low concentrations. 1,5NDS and 1,3,6NTS are also mentioned.

As far as biodegradability is concerned, the test results cannot be easily compared. Depending on the molecular structure, there are big differences among them. Several purification steps are necessary for removal in drinking water preparation. Few data exist about toxicity and ecotoxicity of polar aromatic sulphonates, presumably because they mainly serve as semi-finished products and not as final products. It is assumed that they are less toxic than comparable non-sulphonated compounds and, in general, very toxic compounds become considerably less toxic after being sulphonated. However, more detailed studies are recommended. This report is published in English.

Inventory and toxicological evaluation – revision 1999 (2000)

ASSOCIATION OF RIVER WATERWORKS

RIWA

March/Maart 2000

Inventory and toxicological evaluation
of organic micropollutants

Inventarisatie en toxicologische evaluatie
van organische microverontreinigingen

Revision/Herziening 1999

kiwa

Dr. J. van Genderen
Drs. M.N. Mons
Ing. J.A. van Leerdam

This report is a general revision of the report with the same name from 1994, with 947 organic compounds which were found in 1983-1993 in the water of the Rhine, Meuse, IJsselmeer and Haringvliet and partly in drinking water prepared from it. The report is updated regularly because analysis methods, toxicological insights and the presence of substances change. Since 1983, a total of 1328 organic micro-contaminants were detected at least once in the water examined. Of these, 58 compounds are marked as suspect mutagenic and/or suspect carcinogenic.

The selection criteria for priority substances were updated. Included are possible mobility in purification, the standards of the Waterworks decision including revision and the standards of the EC drinking water directive. The TTL ("Toxicological threshold of no concern"), especially useful when no toxicological data are available, is new. The list of priority substances (covering 1994-1998) has been updated considerably in comparison to the previous one and now contains 19 substances (16 substances are dropped; 5 are new). More aromatic halogen compounds and fewer aliphatic halogen compounds and polycyclic aromatic hydrocarbons are included in the list.

To date, no indications have been found for harmful effects on public health due to organic micro-contaminations in drinking water. It is difficult to estimate, because relevant toxicological data are not available for about one-third of the substances. Too little is known yet about possible combination effects of the substances detected. There are few data on the total daily absorption of these substances and on the share of drinking water in it, although this is assumed to be small. The report is published in two languages (Dutch/English).

Selection and identification of unknown substances (2000)

VERENIGING VAN RIVIERWATERBEDRIJVEN

RIWA

April 2000

Selectie en identificatie
van onbekende stoffen

ing. R. de Groot

Various water companies screen the surface water for organic micro-contaminations by means of gas chromatography-mass spectrometry. Mass spectra of unknown substances are found regularly. This report describes the selection of unknown substances and explains their structure. By comparing the lists with spectra, 8 substances could already be immediately identified. On the basis of frequency and concentration, 20 substances were selected. 6 substances were selected from these for presence in Rhine and/or Meuse water as well as in drinking water.

Meuse water samples from September 1996 and November 1997 were made available for identification of the 6 substances. The extracts were examined with capillary gas chromatography in combination with the following detection techniques: Chemical Ionisation Mass spectrometry (CIMS), Mass spectrometry-mass spectrometry (MSMS), High Resolution Mass spectrometry (HRMS), Fourier Transformation Infrared Spectrometry (FTIR).

3 substances were fully identified: bi(2-methoxy-ethyl)ether, 2,2-dimethoxy-3-methyl-butane and 2,2-dimethoxy-pentane. Of the other 3 compounds the

molecular weight and elementary composition could be determined and a suggestion was made as to the structure. A total of 11 compounds were identified, including the 8 substances from the preparatory phase. Mass spectrometry appears to yield the most valuable information, while certain functional groups in compounds can be confirmed by FTIR. Utilising HRMS, CIMS and MSMS techniques already in an early stage is recommended. FTIR can be applied to concentrations of more than 1 µg/l. There is a proposal to carry out such a study once every five years. The report was published in only Dutch.

The impact of the hydrological intervention in the Meuse (2000)

VERENIGING VAN RIVIERWATERBEDRIJVEN

RIWA

Maart 2000

De impact van de
hydrologische ingrepen
in de Maas

An inventory was made on the effects of a number of hydrological intervention operations in the Meuse on the drinking water function of this river. Due to the very limited information about the French and Wallonian Meuse watershed, the focus was mainly directed towards two Dutch projects: Grensmaas and Zandmaas/Maasroute. In the beginning of the 90s, the province of Limburg initiated a project in the Grensmaas valley to put an end to the Limburg gravel extraction in such a manner that the river would be given more room and ecological recovery and nature development would become possible. After the high water levels at the end of 1993 and beginning of 1995, high water protection became a third objective. From that time on, nature development was combined with giving the river more room within the framework of the Big River Delta Plan. The Zandmaas project served to limit future flooding in the north Meuse. The purpose of the Maasroute project was to modernise the Meuse as a navigation route for professional navigation. Since both projects involved just about the same stretch of the Meuse, the decision to join them was made in 1995. Nature development plays a lesser role in this combined project.

In the Grensmaas project, the water is given more room by widening the channel and lowering the weir. In the Zandmaas/Maasroute project the summer bed is also widened and deepened and high water channels are dredged. Nature-friendly banks will also be realised. Both projects will have an effect on the drinking water function of the Meuse. During the work, the water may become considerably more muddy due to (contaminated) sludge, while the same may be the case in the long run for the freely eroding banks. The water will remain in the same area for a longer time during discharge in dry periods as a result of widening the river bed and realising parallel and high-water channels, at the risk of increasing the growth of algae. A shift to blue algae is expected in this process, which may be an obstacle for drinking water preparation as a result of their toxins, odour and taste substances. There may be more frequent and more extreme high and low water periods due to climate changes. In that case, long-term dry periods can especially pose problems to drinking water provision. Following the projects within the framework of Meuse High Water and the International Meuse Commission is recommended, as well as the procedures concerning the Grensmaas and the Zandmaas/Maasroute. It is also proposed to study the effects of climate changes on the Meuse discharge in more detail. The report was published exclusively in a Dutch version.

Discharge data inventory (2000)

RIWA

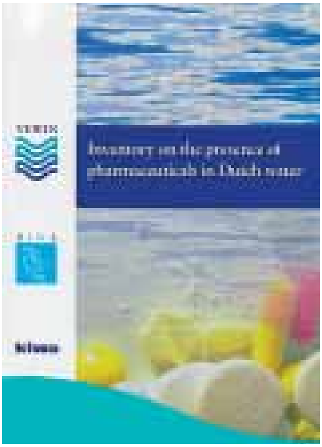
Inventarisatie
lozingsgegevens

The objective was to realise a system in order to obtain information about up-to-date “regular” (non-incidental) discharges in the Rhine and Meuse watersheds quickly.

Various agencies collect information about discharge and the goal was to set up a system containing the most important characteristics of each information system. In addition to Dutch databanks, German, French, Flemish and Wallonian ones would also be explored. In principle, the Dutch agencies that were approached by and large showed their willingness to co-operate with the inventory. As far as set-up and contents were concerned, the following files could be differentiated: 1) individual discharges; permits within the WVO (water managers) framework, 2) aggregated data of specific sectors or business sectors (Ministry of the Environment Emission registration, RIZA, CUWVO, CBS), 3) incidental discharges into (inter)national inland waterways (Federal Water Authority), 4) diffuse sources, mostly known to regional water managers (aggregated data at CBS, Staring Centrum, RIVM, RIZA, KNMI).

After conversations with a number of Dutch agencies, it was decided to focus especially on the first two groups. Next, the order was given for making a prototype for a meta-information system, for which various software companies could submit a bid. After the prototype was realised, during a workshop for RIWA companies and a few water managers, it came to light that support for such a system was minor. The next test was to check to what extent the water quality managers were prepared to provide and were capable of actually providing any data. After only 25% of them appeared to respond positively after two months (having been approached repeatedly), it was decided to halt the project. The conclusion was that it would be better to eliminate the costs for owning a system (with an extensive and expensive management task) and that meanwhile more information could be obtained by means of new technology (CD-ROM) and new media (the Internet). It is true that it is difficult to answer specific questions about discharge files via internet sites, but it is still better to examine to what extent information is found for each question or answer in this manner. This report is available in Dutch.

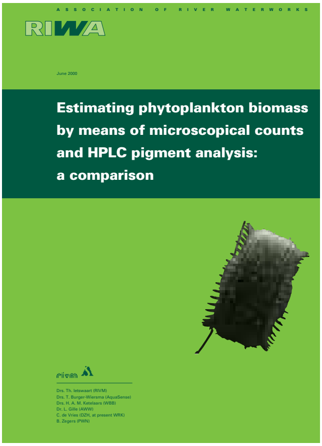
Inventory on the presence of pharmaceuticals in Dutch water (2000)



Recent measurements in Germany and Switzerland have shown the presence of medications in surface water, waste water and drinking water. In 1999, VEWIN, RIWA and Kiwa therefore took measurements at various Dutch locations and one Belgian location on the concentrations of 11 (human) medications in surface water, waste water and drinking water. Although medications may also end up in the environment via animal manure, in addition to via industrial and domestic wastewater, these first measurements were focused on human medications and not those for animals.

No medications were measured in drinking water that exceeded the detection limit, while concentrations in surface and waste water did not exceed 1 µg/l. The highest concentration in surface water (0.31 µg/l) was measured for carbamazepine, which is used to treat schizophrenia, epilepsy and as a painkiller. The highest concentrations were measured in the waste water tested: 0.87 µg/l for carbamazepine and 0.90 µg/l for erythromycin, an antibiotic. Since the therapeutic doses are more than a million times higher than the measured concentrations, undesirable effects via the water appear to be unlikely, although allergic reactions cannot be ruled out completely. Furthermore, new multiple-resistant bacteria could develop in the environment due to antibiotic traces, with all the consequences. In any case, further measurements in drinking, surface and waste water are recommended. A recommendation for mapping the quantities which are produced and used in the Netherlands was elaborated in a substance study which was published in the meantime (see the last report description in this chapter). On the basis of this, new or better analysis methods can be developed and measuring can be more focused. The combined VEWIN, RIWA and Kiwa report is published in English.

Estimating phytoplankton biomass by means of microscopical counts and HPLC pigment analysis: a comparison (2000)



ASSOCIATION OF RIVER WATERWORKS

RIWA

June 2000

Estimating phytoplankton biomass
by means of microscopical counts
and HPLC pigment analysis:
a comparison

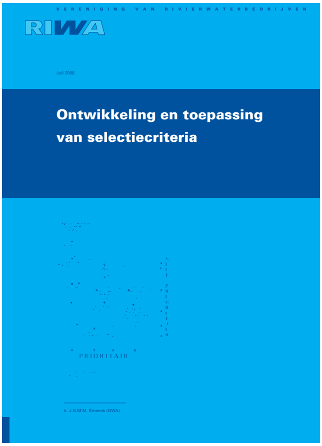
rivm

Drs. Th. Ietswaart (RIVM)
Drs. T. Burger-Wiersma (AquaSense)
Drs. H. A. M. Ketelaars (WBB)
Dr. L. Gille (AWW)
C. de Vries (DZH, at present WRK)
B. Zegers (PWN)

The study of the taxonomic composition of phytoplankton in surface water is often used by surface water managers and water companies because problems with respect to odour, taste, algae quantity and toxic algae can be detected. Usually, the algae composition is determined by counting the cells at microscope level and identifying them. The algae biomass is determined by combining the counts with biovolume analysis. The analysis requires a great deal of patience and specialised know-how, while it has also been demonstrated that differences between laboratories and analysts cannot be ruled out. Meanwhile, a quick and relatively cheap technique has been developed which makes use of the differences in pigment composition between algae groups. Algae pigments are analysed by means of high pressure liquid chromatography (HPLC). The results of comparative studies between the two techniques are described. A ringtest was also carried out with the HLPC method involving six laboratories.

For differentiation of the principal taxonomic algae groups, the results of HPLC pigment analysis, after calibration, appear to be comparable with those of the microscopic counts. For analysis of ten or more samples, the HPLC method takes less than half the time necessary for microscopical counts. Reproducibility of the method is better and the error percentage is also lower. However, the microscopic method provides a more detailed picture of the classes and species in the algae composition, which is not possible with the HPLC method. For general information about the algae composition the HPLC method is a cost and time saving option. For information about the size distribution or about specific species (potentially toxic algae, for example), we will remain dependent on the microscopic method. The report is published in English.

Development and application of selection criteria (2000)



VERENIGING VAN RIVIERWATERBEDRIJVEN

RIWA

Juli 2000

Ontwikkeling en toepassing van selectiecriteria

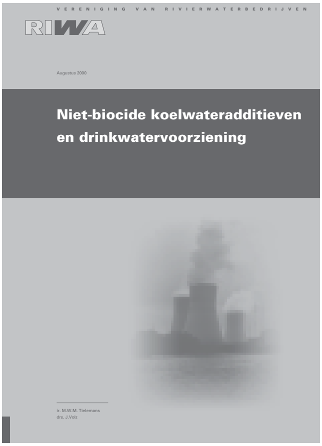
PRIORITAIR

ir. J.G.M.M. Smeenk (GWA)

The number of substances which may end up in surface water from production and use increases annually. Since only a limited part of this can be monitored by measurements, an objective selection of priority substances is necessary. The report formulates basic assumptions for setting priorities and discusses their application. It is postulated that the criteria can be applied to substances studied and (with limitations) to non-researched substances.

For non-researched substances a model priority system, such as the USES model (Uniform System for the Evaluation of Substances) appears to be very desirable. Even though USES has only limited application for the time being, further development must nevertheless be supported. A decision schedule is recommended for setting priorities of substances studied, which is included in the supplement of the report. It involves a reviewed version of the priority setting schedule from the “Inventory and toxicological evaluation – 1999 revision” report. Future adjustment of the decision schedule is not ruled out, especially as far as pseudo-oestrogenic and medication effects are concerned. A study must also be devoted to the manner in which the degradability of a substance can be involved in the schedule. Just as in the case of the USES model, the results of the decision schedule must be evaluated by experts. The report was published in Dutch.

Cooling water additives and drinking water provision (2000)



VERENIGING VAN RIVIERWATERBEDRIJVEN

RIWA

Augustus 2000

Niet-biocide koelwateradditieven
en drinkwatervoorziening

ir. M.W.M. Tielemans
drs. J.Volz

In electricity plants and industries, auxiliary substances are often added to control biological growth and prevent corrosion and formation of deposits in the cooling system. While the RIZA studied emissions of biocides from cooling systems during the past few years, the risks of non-biocide cooling water additives were inventoried in RIWA context. Of the approx. 12 billion m^3 of cooling water used in the Netherlands, about 98% originates from surface water. More than 99% of this is used in flow-through cooling systems, where oxidation biocides are usually used exclusively (mainly based on active chlorine). In recirculation systems, however, agents other than biocides are also added in many cases to prevent corrosion and formation of deposits. This mainly involves organic additives such as phosphonates, acrylates and sulphonated co-polymers.

The toxicity of the phosphonates and polymers in use seems to be minor, in general; too little is known about this for tolytriazol. Phosphonates are relatively easy to remove in drinking water purification. Nothing is known about tolytriazol in this aspect either. Based on the data available (use, toxicity, expected action in purification, etc.) priorities were set, and six non-biocidal additives (five phosphonates and tolytriazol) were selected. When methods were sought at that time, in co-operation with RIZA, for determining the selected substances in surface water and discharges, it turned out these did not exist.

The risks to drinking water provision of the non-biocidal cooling water additives under study seem to be minor. There is no apparent reason for developing additional analysis methods nor for measurements. However, one point of concern is the phosphonates, because this group also includes compounds which can be decomposed into aminomethylphosphonic acid (AMPA). Despite its minor toxicity, the substance is also known as the breakdown product of glyphosate and therefore tied to the pesticide standards of 0.1 µg/l. The drinking water sector must reflect on possibilities of reducing the presence of phosphonate in the aquatic environment, even more because this group of substances has a very broad application spectrum. This report is available in Dutch.

Source and environmental fate of natural oestrogens (Substance study) (2000)

VERENIGING VAN RIVIERWATERBEDRIJVEN

RIWA

Augustus 2000

Herkomst en lot van natuurlijke
oestrogenen in het milieu

HASKONING

drs. J. Blok (Haskoning)
ir. M.A.D. Wösten (Haskoning)

ASSOCIATION OF RIVER WATERWORKS

RIWA

December 2000

Source and environmental fate
of natural oestrogens

HASKONING

Drs. J. Blok (Haskoning)
Ir. M.A.D. Wösten (Haskoning)

During the past few years there has been a great deal of interest in the effects of mainly synthetic substances which may upset hormonal regulation. However, at the same time it is important to know whether the excretion of natural and synthetic sexual hormones can pose risks to humans and animals. In this study, the quantities of oestrogens (for the Netherlands) are calculated which originate in faeces and urine of humans and livestock and which end up via sewers, ditches and temporary water storage system, respectively, in the greater surface water. Furthermore, the distribution and decomposition of these substances in the environment, measured concentrations and possible risks to humans, mammals and the ecosystem are examined.

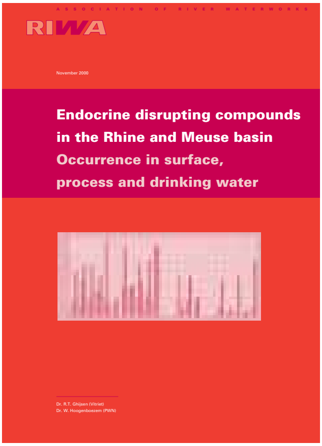
It is estimated that the Dutch population secretes 3.2 kg of natural hormones per day and 43 grams of the synthetic ethinyloestradiol, originating from the contraceptive pill. Concentrations of 50 ng/l of natural hormones are calculated for sewer water purification effluent (at 95% purification return) and of 6.5 ng/l of ethinyloestradiol (at 50% return). If a dilution by a factor 20 is assumed for mixing sewer water with river water, concentrations of natural hormones and ethinyloestradiol can be expected in surface water from 2.5 to 3.0 ng/l.

The Dutch livestock produces (dominated by breeding sows and pregnant cows) about ten times the amount of oestrogens as the human population does, which comes out to about 46 kg of oestrogen per day. If the maximum quantity of slurry from breeding sows or milk cows is carried off in a manure period of three months, the concentration in drainage ditches may increase to 150 ng/l. In such a period, concentrations of 75 ng/l could be measured in the surface water of the Rhine watershed, in the one of the Meuse concentrations of up to 140 ng/l. In case of even distribution (of cow manure, for example) over the half year around the summer, concentrations would be lower, at 40 ng/l for the Rhine and 90 ng/l for the Meuse.

Even though higher hormone concentrations were shown in the effluent of Dutch water purification installations, the highest concentration of natural hormones measured in Dutch surface water is 6 ng/l. In three-quarters of the surface water measurements the concentrations for the various oestrogens were below the 0.1 to 2.4 ng/l detection limit. Ethinyloestradiol has been found in the Netherlands in concentrations of 0.06 and 0.3 ng/l. Measuring results from various countries demonstrate together that especially ethinyloestradiol and oestron are present in the highest concentrations in both sewer water purification effluent and surface water. Still, the measured oestrogen concentrations in the Netherlands surface water are quite variable and not representative for absorbing hormones via animal manure, because the measurements were not taken during fertilising periods.

Ethinyloestradiol is more persistent than the natural oestrogens. This substance is the only one also measured in Dutch drinking water. The prevailing opinion is that the risk to humans via drinking water is non-existent, since the measuring results from various countries only result in concentrations several thousand times below the effective doses. Effects on the ecosystem (especially fish) can be expected in ditches and temporary water storage systems especially during the time fields are fertilised with manure. Such effects can also occur in small bodies of water at discharge points of purified and non-purified city waste water. The report is available in both English and Dutch.

Endocrine disrupting compounds in the Rhine and Meuse basin (2000)



ASSOCIATION OF RIVER WATERWORKS

RIWA

November 2000

Endocrine disrupting compounds
in the Rhine and Meuse basin
Occurrence in surface,
process and drinking water

Dr. R.T. Ghijsen (Vitriet)
Dr. W. Hoogenboezem (PWN)

A number of Dutch government agencies, responsible for the surface water quality in river and coast areas, carried out a large national study on the presence of hormone-disrupting substances in water in the Rhine and Meuse watershed (National Oestrogen Compound Study – LOES). In addition to RIZA, RIKZ, RIVM and the Friesland Water Authority, RIWA also participated in the study, which covered all relevant environmental compartments. Anticipating the complete report on the study, RIWA had a separate report drawn up in 2000 about its share which was focused on fresh surface water, process and drinking water and also extended beyond the national borders.

In the RIWA component, various hormones (oestradiol, oestron, ethinyl-oestradiol), bisphenol A, nine phtalates and alkylphenolethoxylates were measured. The oestrogen activity was measured by the ER-Calux test. Sampling was done in March, June and September 1999 at 12 Rhine locations (Germany and the Netherlands) and at 11 Meuse locations (Belgium and the Netherlands). In addition, process and drinking water were studied.

In drinking water, oestrogen substances were demonstrated only sporadically and in low concentrations. They were measured regularly in surface water and process water, sometimes in high concentrations. Yet, no oestrogen activity was measured in the ER-Calux test which could have an immediate effect in live organisms.

The oestrogen activity did not usually correspond with the measured concentrations of substances. One time the measured activity appeared to be higher than could be explained from the substances detected, the other time lower. Presumably there are more substances which play a role in oestrogen activity and there are also signs of synergy. On the other hand, inhibiting factors may have played a role. Oestrogen activity in the Meuse water appears to be twice as high as in the Rhine water. Furthermore, it is striking that the oestrogen activity in both rivers is highest at the end of the winter, while at that time the water discharge (and the dilution effect) is also at maximum.

Of the oestrogen substances, the (natural and synthetic) hormones are the most powerful. They were measured once in a while in surface water, but not in process and drinking water. Bisphenol A was usually measured in higher concentrations in the Rhine than in the Meuse. The concentrations of phtalates in the Meuse were considerably higher, on the other hand, than in those in the Rhine. These substances were found in all water stages. Since the concentrations of the oestrogens measured in surface water were significantly higher than in process and drinking water, it may be assumed that the purification processes play a large role in removing these substances. Pre-purification by means of water basins appears more effective than bank filtration. On the basis of this study, no conclusive statement can be made about the question of whether high concentrations of oestrogen substances will also be removed to a sufficient extent during drinking water preparation. In order to be able to answer such questions, measuring for longer periods at increased frequency (10 to 12 times per year) at two locations per river is recommended. Changes in the supply of oestrogen substances must be taken into account here. Complete the chemical analyses with effect measurements, such as the ER-Calux test and a vitellogenin test, for example, with rainbow trout at the site, is also recommended. The report was published in English.

Cryptosporidium and *Giardia:* occurence in sewage, manure and surface water (2001)

VERENIGING VAN RIVIERWATERBEDRIJVEN

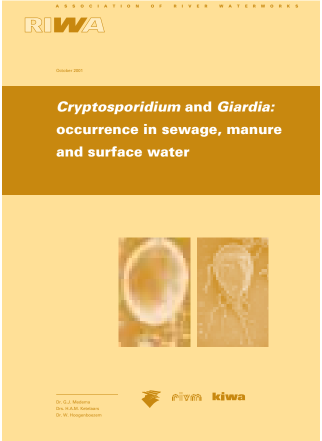
RIWA

januari 2001

***Cryptosporidium* en *Giardia*:**
voorkomen in rioolwater, mest
en oppervlaktewater
met zwem- en drinkwaterfunctie

dr. G.J. Medema
drs. H.A.M. Ketelaars
dr. W. Hoogenboezem

rivm kiwa



ASSOCIATION OF RIVER WATERWORKS

RIWA

October 2001

***Cryptosporidium* and *Giardia*:**
occurrence in sewage, manure
and surface water

Dr. G.J. Medema
Drs. H.A.M. Ketelaars
Dr. W. Hoogenboezem

rivm kiwa

In 1995 and 1996, RIWA carried out its first study on the presence of *Cryptosporidium* and *Giardia* in Rhine and Meuse water and the potential sources (sewer water, slaughterhouses, livestock) were also inventoried. In 1997 and 1998 a follow-up study was carried out in co-operative context between RIVM, RIZA, Kiwa and RIWA on the share of city waste water, manure, manure processing and slaughterhouse waste water as sources of these parasites.

In addition to that, the supply from abroad via Rhine and Meuse was mapped, mainly by measuring at Lobith (Rhine) and Eijsden (Meuse) and the concentration of both parasites was measured at a number of drinking water provision intake points in the Netherlands and Belgium and at three swimming locations. Other parameters (micro-biological, physical and chemical) were also measured in relation to the presence of *Cryptosporidium* oöcysts and *Giardia* cysts.

In the period from June 1997 to May 1998, intake and effluent of two sewage plants (near Amsterdam and Rotterdam) and non-purified sewer water from Liege were sampled 13 to 15 times. The average concentrations in the raw sewage water appeared to differ significantly per location. Neither the differences between the two Dutch cities nor the lower numbers at Liege could be explained. It was calculated that of the total gross emission of *Cryptosporidium* and *Giardia* from households, 5 and 3%, respectively, end up in the Dutch surface water.

In the June 1997-January 1998 period, a large number of samples of manure from fresh meat-calves, milk cows, fryer chickens and laying hens were examined for concentrations of both protozoa. Meat calves constitute an important source of *Cryptosporidium* and *Giardia* (90% turned out to be positive). A quarter of the calf manure is processed, during which thickening process about 80% of the parasites die. Three-quarters of the calf manure ends up on the land and is a potentially large source, but it is unknown to what extent the protozoa end up in the surface water by being flushed out of the meadows. Milk cows appeared to not be a significant source, while no (oö) cysts at all were found in fryer chicken manure. Laying hens are a source of *Cryptosporidium*, but possibly this involves a non-human pathogenic species. Slaughterhouse waste water does not contribute significantly to the protozoa load.

The Rhine and Meuse are the most important sources of *Cryptosporidium* and *Giardia* for the Dutch surface water. At Lobith (Rhine) and Eijsden (Meuse) (14 measurements, May 1997-May 1998) the concentrations are comparable, but due to the ten-times-higher discharge the protozoa load in the Rhine is relatively higher. Thus, the emission in the Rhine watershed must also be significantly higher before crossing the border than in the Meuse upstream, while domestic waste water in Germany is purified almost everywhere and in Belgium mostly not at all. The cause of the higher emission in the Rhine watershed is attributed to the larger number of big cities and the much more extensive agricultural area.

The measurements at the intake points (12 measurements, May 1997-May 1998) showed that the protozoa concentrations in the summer period were relatively low, while in the late summer and fall a rapid increase was visible at most locations. The *Cryptosporidium* and *Giardia* concentration were tightly correlated. In the Meuse, the concentrations of both protozoa are highest at Tailfer and Eijsden, and they drop in the Netherlands territory. The protozoa concentrations also drop in the Rhine within the Netherlands (except one high measuring value for *Giardia* in the Lek canal). The drop in concentration in the Netherlands trajectory is attributed to a combination of dilution (addition of Dutch creek, river and temporary storage water) with dying-off and sedimentation.

Sampling of the three swimming locations (De Bijland, Lobith; De Maasplas, Eijsden; Bovensluis, Hollands Diep) was done during the swimming season (8 measurements, May-September, 1997). Both protozoa were found in all samples. The concentration was comparable to that of other surface water locations. The risk to swimmers depends on how often and how long the location is visited and thus how much water is ingested. In case of frequent visits, there is a considerable risk of being infected by either parasite. The risk level of swimming, in any case, is rather higher than the maximum acceptable annual risk of drinking water consumption. The report, which contains many figures to illustrate the results, was published in Dutch and in English.

Biological tests, a suitable instrument for the quality control of surface water? (2001)

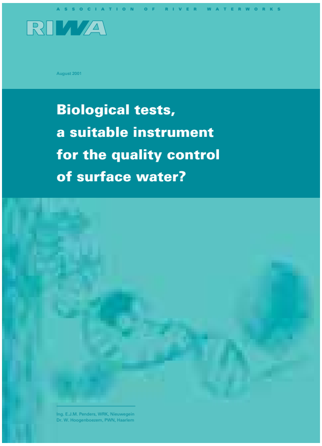
VERENIGING VAN RIVIERWATERBEDRIJVEN

RIWA

januari 2001

Biotesten,
een bruikbaar instrument
voor de kwaliteitsbewaking
van oppervlaktewater?

ing. E.J.M. Penders, WRK, Nieuwegein
dr. W. Hoogenboezem, PWN, Haarlem



ASSOCIATION OF RIVER WATERWORKS

RIWA

August 2001

Biological tests,
a suitable instrument
for the quality control
of surface water?

Ing. E.J.M. Penders, WRK, Nieuwegein
Dr. W. Hoogenboezem, PWN, Haarlem

As was already stated in the report at the beginning of this chapter (HPLC/UV-fingerprint), there is a great deal of interest in biological tests. There are a number of reasons for that interest: a) the surface water contains many more substances than can be measured, b) of the substances that do get measured, what effect they have on organisms is not always known, c) the question is to what extent lower concentrations of a substance are less hazardous, d) a combination of various substances possibly poses more risk than each substance individually. Biotests measure the effect on organisms. Organisms, or parts of these (bacteria, algae, animals, cell cultures or tissues) are exposed to the water to be investigated (or a concentrate), after which responses of the test organisms (drop in activity, reproduction, growth, sometimes death) are registered. Because different substances may cause different effects, various tests must be applied simultaneously in a so-called test battery with, preferably, organisms from different main groups and functions within the ecosystem.

In this project, which biotests are the most suitable for (Dutch) river testing and how the test battery can be composed in the best manner were studied. The results enabled conclusions to be drawn on the water quality of Rhine and Meuse, on the difference between the two rivers and on the variation in toxicity during the seasons. The tests had to meet the following conditions: easy to apply, consuming little time, small volume testing medium, low cost, capacity to be standardised, high sensitivity. Methods used were bioassays (general effect on cells/organisms), genotoxity tests (DNA changes) and two other effect-specific biotests. The battery included the following bioassays: Microtox, Microtiter plate test with 2 species of algae, PAM algae test, Rotoxkit, Thamnotoxkit, Daphnia IQ test. The genotoxicity tests used were: Amestest, UMU test, VITOTOX and 2 comet tests. In addition, cholinesterase inhibition and the oestrogen activity (ER-Calux test) were tested. The biotests were carried out on extracts of bi-monthly samples of water from the Rhine (Lobith) and Meuse (Eijsden).

The most suitable bioassays appeared to be Microtox, Microtiter plate test with 1 species of algae, PAM algae test, Thamnotoxkit, Daphnia IQ test. The results of 7 bioassays demonstrated that the Meuse would be significantly more toxic to organisms than the Rhine. Chemical measurements taken at the same moment showed that the Meuse water contained six organic compounds with an actual toxic share (92%) in the water quality. The concentrations of these substances were all below 0.1 µg/l. In the Rhine, six organic compounds were also demonstrated to be present, which would explain the major share of the toxic effect (88%). Of the genotoxicity tests, the most frequent mutagenic activity was demonstrated with the Ames test (already used by RIWA for many years; see also the description of the second report in this chapter). The VITOTOX and UMU tests only showed results in 70% of the cases. Further validation is considered to be of value for the two comet tests. Useful results were obtained with two additional tests, the SOS Chromo test and the Mutatox test. Just as in previous years, mutagenic activity in the Rhine appeared to be essentially higher than in the Meuse. The lowest mutagenic activity for the Rhine was observed in March; for the Meuse this appeared to be the case in November.

During the effect-specific biotests it was found that the Meuse contains more contamination that inhibits the cholinesterase enzyme than the Rhine does. Only one single measurement in the Rhine demonstrates a rise in quantity of these compounds. Since 1988, these compounds have been found to decrease in quantity in both the Rhine and the Meuse. The ER-Calux test showed that the concentration of hormone disrupters in the Meuse is higher than in the Rhine. A clear increase in activity was shown in one Meuse water sample. The recommendations include, among other things, guidelines to raise effectiveness and mutual comparability of the various tests. Many figures and tables illustrate the test preparations and results of the studies. The report is published in Dutch and English versions.

Environmental effects of human medicines – The presence and risks. (Substance study) (2001)

RIWA VERENIGING VAN RIVIERWATERBEDRIJVEN

RIJKSINSTITUUT VOOR INTEGRAAL ZOETWATERBEHEER EN AFVALWATERBEHANDELING – RIZA

juli 2001

Milieu-effecten
van humane geneesmiddelen
Aanwezigheid en risico's

AquaSense

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RIWA ASSOCIATION OF RIVER WATERWORKS

INSTITUTE FOR INLAND WATER MANAGEMENT AND WASTE WATER TREATMENT – RIZA

September 2001

Environmental effects
of human medicines
The presence and risks

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After the first results of German measurements of (components of) medications were published in 1996, a RIWA literature study showed that only very little was known about this subject – and especially about the situation in the Netherlands. Via initial exploratory measurements in 1999 (see one of the report descriptions above), human medications were also demonstrated in the Netherlands surface and waste water. The objective of this follow-up study is to provide more insight into the potential problems which may be posed by human medications for drinking water, surface water and ground water in the Netherlands. Among others, the following items are discussed: a) emission routes, b) concentrations demonstrated in sewer water, surface water, ground water and drinking water, c) potential risks to humans and organisms by low concentrations in the aquatic environment, d) possible problem substances and selection criteria for these, e) legislation and regulation with respect to ecotoxicological aspects for authorisation in the EU and the US.

Of the medications described in the literature, the most important groups are made up of fibrates and beta-inhibitors (heart and vascular diseases, high blood pressure), anti-convulsants, analgesics (painkillers), oncolytics (cancer), antibiotics, anti-depressants, bronchospasmolytics (asthma, etc.) and iodine-containing X-ray contrasting agents. Measuring data (usually from surface water and sewage plant effluent) for 85 different medications and 10 different metabolites were found in the literature. This involves a very minor percentage of the thousands of effective substances authorised.

Three emission routes are differentiated for human medications: 1) domestic route after use (including hospitals and nursing homes), 2) industrial route after production (small percentage of medication produced), 3) non-consumed medications (8.3% of the prescription medications. Only 3% of this percentage ends up in the sewer, because the majority is collected via pharmacies.) Along emission routes (waste water, sewer water, sewage plants, surface water, groundwater, drinking water) concentrations drop, so that they are usually between the detection limit and a few nanograms per litre in surface water, with a few peaks that exceed one microgram per litre. So far, no medications have been demonstrated in the Netherlands drinking water. Because the concentrations found in the aquatic environment are a million times lower than the therapeutic doses of medications, no harmful side effects are expected for people via drinking water.

For organisms living in the water, a number of negative effects are differentiated in theory: a) effects which can be shown by means of biotests (acute and chronic toxicity, genotoxicity and carcinogenicity), b) effects as result of the pharmacological effect on non-target organisms (influencing hormonal and immune systems), c) resistance development by micro-organisms (bacteria), which would cause antibiotics to lose their effectiveness after some time. Chronic toxicity data have been found only to a limited extent and a sound risk estimate cannot be made. Nevertheless, chronic exposure of water organisms to several medications at the same time must be taken into account. The effects of that combination effect are difficult to gauge and may vary from a simple addition one to another to reinforcing each other or weakening one another instead.

Because a list of the most used medications in the Netherlands was not available, medications were selected for the risk assessment on the basis of expected frequent use, biodegradability, ecotoxicological data, selections abroad and availability of data. 21 human medications were selected from the following 8 substance groups: fibrates and beta-inhibitors, anti-convulsants, analgesics, oncolytics, antibiotics, the anti-depressants, iodine-containing X-ray contrast agents and new medications (such as Viagra). Based on the user numbers, “worst-case” estimates were made of the concentrations in sewage plant intake, canals, creeks and rivers without taking into account conversion, adsorption, decomposition or evaporation of the medications in question. For a proper risk assessment, chronic and specific toxicity data in particular are lacking.

The concentrations actually measured at sewage plants and in the surface water usually appear to lie below the concentrations calculated. Two medications were measured in high concentrations in a nearly all matrices: clofibric acid (heart and vascular medication conversion product) and carbamazepine (anti-convulsant). Both break down with difficulty and scarcely anything is known about their toxicity. Analgesics (pain killers) are found in sewer water, sewage plant effluent and surface water due to the large quantities that are used, but most break down well. Oncolytics occur in very low concentrations, but break down slowly and cause a specific pharmacological effect. Antibiotics also occur in low concentrations, but effects on mainly bacteria and algae start occurring at a few μg/l; relatively a great deal is known about their ecotoxicity. Nearly no measurement data are known about anti-depressants, but some ecotoxicological research was carried out on the SSRIs group (including Prozac), which may already disturb the ecosystem at very low concentrations (already at 0.3 μg/l a stimulating effect is observed in sexual reproduction in mussels). Iodine-containing X-ray contrast agents occur in very high concentrations, while they break down slowly. It could be deduced from tests that they would not pose an unacceptable risk in the near future, but insufficient chronic toxicity data appear to be available. Nearly nothing is known about the ecotoxicological effects of new medications such as Viagra, but because such medications have an effect on a very general enzyme, undesirable effects may take place in non-target organisms.

Many of the statements are displayed by means of tables and the supplement also contains the complete texts of the concept EU directive and the US directive for environmental risk assessment. Recommendations are made concerning setting priorities for problem substances, chemical monitoring, both generic and specific risk analyses for the aquatic environment, development of resistance and international collaboration. The report is available in Dutch and English versions.

English translations

Two substance studies which were published in 1998 have since been published in English versions:

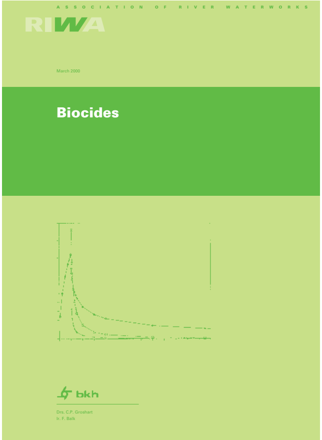
- Fragrance ingredients
- Biocides.

ASSOCIATION OF RIVER WATERWORKS
RIWA

March 2000

Fragrance Ingredients

Ir. F. Balk
Ir. A.L.M. Rutten



ASSOCIATION OF RIVER WATERWORKS
RIWA

March 2000

Biocides

Drs. C.P. Groshart
Ir. F. Balk

Supplements

RIWA member companies (September 2001) **Supplement 1**

Brusselse Intercommunale Watermaatschappij

Gemeentewaterleidingen, Amsterdam

Intercommunale Vennootschap Antwerpse Waterwerken N.V.

N.V. DELTA Nutsbedrijven, Middelburg

N.V. Duinwaterbedrijf Zuid-Holland, Voorburg

N.V. Hydron Midden-Nederland, Utrecht

N.V. Hydron Zuid-Holland, Gouda

N.V. PWN Waterleidingbedrijf Noord-Holland, Velserbroek

N.V. Waterbedrijf Europoort, Rotterdam

N.V. Waterleiding Maatschappij Limburg, Maastricht

N.V. Waterleiding Maatschappij Noord-West-Brabant, Breda

N.V. Waterleidingmaatschappij Oost-Brabant, ’s-Hertogenbosch

N.V. Watertransportmaatschappij Rijn-Kennemerland, Amsterdam

N.V. Waterwinningbedrijf Brabantse Biesbosch, Werkendam

Tussengemeentelijke Maatschappij der Vlaanderen voor Watervoorziening, Ghent

Vlaamse Maatschappij voor Watervoorziening, Brussels

Waterleiding Maatschappij Overijssel N.V., Zwolle

The quality of the Rhine water at Lobith in 1999

Supplement 2A

(monthly averages and index numbers)

Parameter	unit	n	d.l.	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**June**	**July**
General parameter										
Water discharge	m^3/s	365		2709	3820	4751	3219	3454	3302	2473
Temperature	°C	357		6.5	5.3	8.2	11.8	16	18.9	21.9
Oxygen, dissolved	mg/l O_2	357		12	12.2	11.4	10.9	10.4	9.6	9.3
Oxygen saturation	%	357		97	96	95	97	97	90	85
Suspended matter	mg/l	314	2	21.7	47.1	40.4	24.4	40.9	30	22.5
Residual ß-radioactivity (tot.-K40)	Bq/l	13		0.031	0.23	0.024	0.048	0.12	0.034	0.048
Tritium	Bq/l	13		3	4	6	5	5	5	3
pH-value	pH	351		7.69	7.67	7.69	7.8	8.06	7.96	7.99
Inorganic substances										
ECC (electrical conductivity at 20°C)	mS/m	344		73	68	57	62	59	57	64
Bicarbonate	mg/l HCO_3	13		164	148	176	165	188	179	170
Fluoride	mg/l F	6			0.13		0.11		0.09	
Bromide	mg/l Br	13	1	<	<	<	<	<	<	<
Chloride	mg/l Cl	340		96	85	64	78	67	68	87
Sulphate	mg/l SO_4	26		61	57	47	55	49	44	49
Sodium	mg/l Na	26		52.5	46.3	43	51.9	38.9	44.3	61.7
Potassium	mg/l K	13		4.9	4.4	4.6	4.2	3.5	3.9	4.8
Calcium	mg/l Ca	13		75	70	72	68	75	70	68
Magnesium	mg/l Mg	13		12.5	11.94	10.84	10.7	9.95	9.93	10.15
Total hardness	mmol/l	13		62.5	57.76	60.76	57.4	64.75	59.87	58.15
Total cyanide	µg/l CN	6	3		<		<		<	
Eutrophying substances										
Ammonia	mg/l N	26	0.01	0.19	0.15	0.17	0.1	0.08	0.04	0.05
Kjeldahl nitrogen	mg/l N	26	0.1	0.65	0.85	0.55	0.8	0.42	0.7	0.95
Nitrate	mg/l N	26		4.12	4.2	3.3	3.49	2.39	2	2.07
Orthophosphate	mg/l P	26		0.093	0.085	0.068	0.064	0.032	0.047	0.089
Total phosphate	mg/l P	26		0.19	0.32	0.14	0.11	0.16	0.12	0.14
Heavy metals										
Iron	mg/l Fe	13		0.75	7.4	0.79	0.84	3.33	1.16	0.81
Manganese	mg/l Mn	13		0.06	0.25	0.05	0.05	0.12	0.06	0.05
Aluminium	µg/l Al	13		177	1380	183	202	409	332	199
Antimony	µg/l Sb	13	0.01	0.3	0.48	0.1	0.22	0.48	<	<
Arsenicum	µg/l As	13		1.2	4.2	1.3	1.3	2.8	1.6	1.7
Barium	µg/l Ba	13		115	104	91	71	72	79	81
Boron	mg/l B	13		0.1	0.06	0.07	0.06	0.05	0.06	0.08
Cadmium	µg/l Cd	26	0.05	0.08	0.18	0.06	<	0.08	<	0.06
Chromium	µg/l Cr	26		2.35	5.8	2.55	2.2	6.25	2.5	2
Copper	µg/l Cu	26		2.9	9	3.8	2.9	5.8	3.7	3.9
Mercury	µg/l Hg	26		0.014	0.05	0.015	0.014	0.032	0.025	0.019
Lead	µg/l Pb	26		1.9	8.2	2.9	2.3	4	2.5	2.5
Nickel	µg/l Ni	26		2.9	8	2.8	2	4.3	2.6	1.6
Selenium	µg/l Se	6	0.01		0.3		<		0.16	
Zinc	µg/l Zn	26		16	39	16	15	20	12	13

n	number of observations during the year under review	min.	minimum
d.l.	detection limit	av.	average
10%, 50%, 90%	10%, 50%, 90% of the measurements are beneath the reported value	max.	maximum

Parameter	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**	min.	av.	max.	10%	50%	90%
General parameter											
Water discharge	1782	1356	1728	1672	3510	1136	2811	7920	1508	2633	4283
Temperature	21.9	21.4	14.7	10.3	6.9	4.5	13.9	24	5.9	13.4	22
Oxygen, dissolved	9	8.6	9.8	10.8	11.7	8.2	10.4	13.2	8.7	10.5	12
Oxygen saturation	82	79	90	93	96	74	91	113	80	93	98
Suspended matter	21.4	19.5	14.9	14.3		<	27.7	180	14	23	42
Residual ß-radioactivity (tot.-K40)	0.032	0.042	0.052	0.021	0.084	0.018	0.065	0.23	0.021	0.042	0.12
Tritium	7	5	3	7	4	3	5	7	3	5	6
pH-value	7.84	7.74	7.8	7.8	7.81	7.58	7.83	8.36	7.65	7.79	8.07
Inorganic substances											
ECC (electrical conductivity at 20°C)	69	84	78	84	79	36	69	98	54	68	86
Bicarbonate	172	173	162	174	157	134	168	188	148	172	179
Fluoride	0.12		0.12		0.16	0.09	0.12	0.16			
Bromide	<	<	<	<	<	<	<	<	<	<	<
Chloride	97	136	120	126	108	42	95	173	60	92	135
Sulphate	56	70	64	65	58	39	56	75	42	57	65
Sodium	53	87.8	73.7	79.3	56.3	30.5	56.8	95	36.8	52	80.6
Potassium	4.8	5.4	5.5	6.3	5.2	3.5	4.8	6.3	3.9	4.8	5.5
Calcium	71	71	72	83	76	66	73	86	68	71	75
Magnesium	11.11	10.9	12.38	12.38	11.79	9.93	11.26	13.11	9.95	10.9	12.38
Total hardness	60.29	60.5	59.22	70.42	64.26	55.43	61.55	73.09	57.4	60.29	64.75
Total cyanide	<		<		<	<	<	<			
Eutrophying substances											
Ammonia	0.05	0.05	0.05	0.05	0.12	<	0.09	0.23	0.03	0.08	0.18
Kjeldahl nitrogen	0.75	0.65	1.25	1.45	0.37	<	0.76	2.6	0.2	0.75	1
Nitrate	2.27	2.4	2.08	1.18	1.35	0.6	2.5	4.43	1.37	2.21	3.97
Orthophosphate	0.074	0.084	0.101	0.097	0.104	0.015	0.078	0.113	0.048	0.082	0.104
Total phosphate	0.14	0.14	0.15	0.13	0.33	0.11	0.18	0.48	0.11	0.14	0.21
Heavy metals											
Iron	0.61	0.92	0.78	0.57	2.79	0.41	1.81	7.4	0.57	0.81	3.33
Manganese	0.05	0.06	0.06	0.04	0.11	0.04	0.08	0.25	0.04	0.06	0.12
Aluminium	152	250	190	124	719	106	387	1380	124	199	409
Antimony	0.24	<	<	0.36	0.29	<	0.21	0.48	<	0.22	0.4
Arsenicum	1.5	1.7	1.6	1.5	2.15	1.2	1.9	4.2	1.3	1.6	2.8
Barium	96	91	79	97	85	71	88	115	72	86	97
Boron	0.1	0.11	0.1	0.12	0.08	0.05	0.08	0.12	0.05	0.08	0.1
Cadmium	0.05	0.09	0.05	0.09	0.12	<	0.08	0.3	<	0.06	0.1
Chromium	1.4	1.05	0.95	0.8	1.43	0.5	2.4	10	0.7	1.8	3.3
Copper	3.8	4.6	3.9	3.8	7.7	2.7	4.7	13	3.1	3.9	7.5
Mercury	0.021	0.032	0.018	0.012	0.036	0.009	0.024	0.059	0.011	0.019	0.042
Lead	2.3	3.9	2.3	1.8	7.2	1.5	3.6	13	1.8	2.5	5.9
Nickel	1.7	2.2	1.3	1.3	5.3	0.7	3.1	11	1	2.2	6.5
Selenium	0.1		0.44		0.4	<	0.23	0.44			
Zinc	12	18	13	14	45	9	20	72	12	15	25

Parameter	unit	n	d.l.	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**June**	**July**
Organic substances, individual compounds										
Volatile chlorinated hydrocarbons										
dichloromethane	µg/l	13	0.01	0.01	0.01	0.01	0.06	0.01	0.01	0.01
1,2-dichloroethane	µg/l	13	0.01	0.03	0.01	0.02	0.06	0.02	0.01	0.01
1,2-dichloropropane	µg/l	13	0.01	<	<	0.01	0.01	<	<	0.01
cis 1,3 dichloropropene	µg/l	13	0.01	<	<	<	<	<	<	<
trans 1,3 dichloropropene	µg/l	13	0.01	<	<	<	<	<	<	<
trichloromethane	µg/l	13		0.05	0.02	0.02	0.02	0.01	0.02	0.01
1,1,1-trichloroethane	µg/l	13	0.01	<	<	<	<	<	<	<
trichloroethene	µg/l	13	0.01	0.02	0.02	0.01	0.01	0.01	0.01	0.01
1,2,3-trichloropropane	µg/l	13	0.01	<	<	<	<	<	<	<
tetrachloromethane	µg/l	13	0.01	<	<	<	<	<	<	<
tetrachloroethene	µg/l	13		0.07	0.04	0.04	0.03	0.02	0.01	0.02
dibromochloromethane	µg/l	13	0.01	<	<	<	<	<	<	<
tribromomethane	µg/l	13	0.01	0.01	<	<	0.01	<	<	<
Chlorophenoles										
2,3,4-trichlorophenol	µg/l	11	0.01	<	<	<	<	<	<	
2,3,6-trichlorophenol	µg/l	11	0.01	<	<	<	<	<	<	
2,4,5-trichlorophenol	µg/l	11	0.01	<	<	<	<	<	<	
2,4,6-trichlorophenol	µg/l	11	0.01	0.01	<	<	<	<	<	
3,4,5-trichlorophenol	µg/l	11	0.01	<	<	<	<	<	<	
2,3,4,5-tetrachlorophenol	µg/l	11	0.01	<	<	<	<	<	<	
pentachlorophenol	µg/l	11	0.01	0.03	<	<	<	<	<	
Volatile aromatic hydrocarbons (MAC)										
methylbenzene	µg/l	13	0.01	<	<	<	<	<	<	<
benzene	µg/l	13	0.01	0.01	0.01	0.02	0.01	<	0.01	<
1,2-dimethylbenzene	µg/l	13	0.01	<	<	<	<	<	<	<
ethylbenzene	µg/l	13	0.01	<	<	<	<	<	<	<
ethenylbenzene	µg/l	13	0.01	<	<	<	<	<	<	<
Polycyclic aromatic hydrocarbons (PAH)										
benzo(b)fluoranthene	µg/l	6	0.005		0.088		0.01		0.012	
benzo(k)fluoranthene	µg/l	6	0.005		0.037		<		<	
benzo(ghi)perylene	µg/l	6	0.005		0.041		<		<	
benzo(a)pyrene	µg/l	6	0.005		0.068		0.005		0.005	
fluoranthene	µg/l	6			0.13		0.017		0.012	
indeno (1,2,3-cd)pyrene	µg/l	6	0.005		0.048		0.006		0.006	
PAH, 6 of Borneff	µg/l	6			0.41		0.04		0.04	
anthracene	µg/l	6	0.005		0.012		<		<	
benzo(a)anthracene	µg/l	6	0.005		0.062		<		0.005	
chrysene	µg/l	6	0.005		0.077		0.006		0.006	
dibenzo(a,h)anthracene	µg/l	6	0.005		0.006		<		<	
phenantrene	µg/l	6	0.05		0.058		<		<	
naphtalene	µg/l	6			<		<		0.05	
fluorene	µg/l	6	0.005		0.012		0.007		0.006	
pyrene	µg/l	6			0.11		0.01		0.012	

Parameter	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**	min.	av.	max.	10%	50%	90%
Organic substances, individual compounds											
Volatile chlorinated hydrocarbons											
dichloromethane	<	0.01	<	0.01	0.01	<	0.01	0.06	<	0.01	0.01
1,2-dichloroethane	0.01	0.04	0.02	0.03	0.01	<	0.02	0.06	0.01	0.02	0.03
1,2-dichloropropane	<	0.01	<	<	<	<	<	0.01	<	<	0.01
cis 1,3 dichloropropene	<	<	<	<	<	<	<	<	<	<	<
trans 1,3 dichloropropene	<	<	<	<	<	<	<	<	<	<	<
trichloromethane	0.02	0.01	0.01	0.11	0.09	0.01	0.04	0.15	0.01	0.02	0.05
1,1,1-trichloroethane	<	<	<	<	<	<	<	<	<	<	<
trichloroethene	<	0.01	0.01	0.01	0.01	<	0.01	0.02	0.01	0.01	0.02
1,2,3-trichloropropane	<	<	<	<	<	<	<	<	<	<	<
tetrachloromethane	<	<	<	<	<	<	<	<	<	<	<
tetrachloroethene	0.03	0.04	0.01	0.03	0.03	0.01	0.03	0.07	0.01	0.03	0.04
dibromochloromethane	<	<	<	0.02	<	<	<	0.02	<	<	<
tribromomethane	<	0.01	<	0.01	<	<	<	0.01	<	<	0.01
Chlorophenoles											
2,3,4-trichlorophenol		<	<	<	<	<	<	<	<	<	<
2,3,6-trichlorophenol		<	<	<	<	<	<	<	<	<	<
2,4,5-trichlorophenol		<	<	<	<	<	<	<	<	<	<
2,4,6-trichlorophenol		<	<	<	<	<	<	0.01	<	<	<
3,4,5-trichlorophenol		<	<	<	<	<	<	<	<	<	<
2,3,4,5-tetrachlorophenol		<	<	<	<	<	<	<	<	<	<
pentachlorophenol		<	<	<	<	<	<	0.03	<	<	<
Volatile aromatic hydrocarbons (MAC)											
methylbenzene	<	<	<	<	<	<	<	<	<	<	<
benzene	<	<	<	<	<	<	<	0.02	<	<	0.01
1,2-dimethylbenzene	<	<	<	<	<	<	<	<	<	<	<
ethylbenzene	<	<	<	<	<	<	<	<	<	<	<
ethenylbenzene	<	<	<	<	<	<	<	<	<	<	<
Polycyclic aromatic hydrocarbons (PAH)											
benzo(b)fluoranthene	0.008		<		0.008	<	0.021	0.088			
benzo(k)fluoranthene	<		<		<	<	0.008	0.037			
benzo(ghi)perylene	<		<		0.006	<	0.01	0.041			
benzo(a)pyrene	0.005		<		0.007	<	0.015	0.068			
fluoranthene	0.02		0.006		0.018	0.006	0.034	0.13			
indeno (1,2,3-cd)pyrene	0.005		<		0.006	<	0.012	0.048			
PAH, 6 of Borneff	0.04		0.02		0.05	0.02	0.1	0.41			
anthracene	<		<		<	<	<	0.012			
benzo(a)anthracene	0.005		<		0.007	<	0.014	0.062			
chrysene	0.007		<		0.009	<	0.018	0.077			
dibenzo(a,h)anthracene	<		<		<	<	<	0.006			
phenantrene	<		<		<	<	<	0.058			
naphtalene	<		0.01		<	0.01	0.03	0.05			
fluorene	0.006		<		<	<	0.006	0.012			
pyrene	0.014		0.005		0.014	0.005	0.028	0.11			

Parameter	unit	n	d.l.	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**June**	**July**
Complexing agents										
EDTA	µg/l	13	5	6	6	<	<	6	6	8
Organic substances, sum and group parameters										
Dissolved organic carbon (DOC)	mg/l C	26		3.5	2.5	3.5	2.5	3	2.3	1.5
Colour intensity, Pt/Co-scale	mg/l Pt	6			16		19		8	
Non-ionic + cationic detergents	mg/l	6	0.02		0.08		0.04		<	
AOX (adsorbable organic halogens)	µg/l Cl	25	1	11.5	16.5	48.5	32	39	10.8	21
Cholinesterase inhibition	µg/l para	13	0.1	0.39	0.28	0.16	0.25	0.29	0.12	<
Algae biomass										
Chlorophyll-a	µg/l	25		1	4	5	14	54	23	15
Pheophytine	µg/l	25		2	4	2	5	20	10	9
Bacteria										
Thermotolerant bacteria, Coligroup	n/100 ml	25		3850	5150	2800	1260	685	1267	3315
Escherichia coli	n/100 ml	25		4400	4750	2450	1045	405	750	2560
Faecal streptococci	n/100 ml	23		1560	1765	840	50	50	13	3

Parameter	Aug.	Sep.	Oct.	Nov.	Dec.	min.	av.	max.	10%	50%	90%
Complexing agents											
EDTA	6	8	7	14	8.5	<	6.46	14	<	6	8
Organic substances, sum and group parameters											
Dissolved organic carbon (DOC)	2.5	2.5	2.5	3	4	1	2.8	5	2	3	4
Colour intensity, Pt/Co-scale	8		14		10	8	13	19			
Non-ionic + cationic detergents	0.06		0.07		0.06	<	0.05	0.08			
AOX (adsorbable organic halogens)	25.5	44	47	24	69	<	32.7	81	13	27	55
Cholinesterase inhibition	<	<	0.21	<	0.18	<	0.17	0.39	<	0.16	0.28
Algae biomass											
Chlorophyll-a	13	6	2	1	3	1	10	54	1	5	16
Pheophytine	9	7	3	2	6	1	6	20	2	5	10
Bacteria											
Thermotolerant bacteria, Coligroup	1620	2575	1025	6400	2820	170	2529	8100	450	1400	6300
Escherichia coli	1750	1935	710	2600	2273	140	2067	7900	470	1600	4200
Faecal streptococci	130	125	110	620	475	0	471	2800	0	90	880

The quality of the Rhine water at Lobith in 2000

Supplement 2B

(monthly averages and index numbers)

Parameter	unit	n	d.l.	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**June**	**July**
General parameter										
Water discharge	m^3/s	366		2966	3971	3745	2461	2147	2129	2222
Temperature	°C	324		6.3	7.1	9.1	12.7	18.8	20.9	19.8
Oxygen, dissolved	mg/l O_2	329		11.7	11.8	11.2	11.1	9.9	9.2	8.6
Oxygen saturation	%	323		94	96	95	100	92	85	80
Suspended matter	mg/l	366		23.9	32.6	23.4	19.6	20.3	19.6	20.5
Residual ß-radioactivity (tot.-K40)	Bq/l	13		0.034	0.056	0.026	0.042	0.026	0.034	0.036
Tritium	Bq/l	13		4	2	3	5	5	4	7
pH-value	pH	328		7.83	7.84	7.74	7.9	7.84	7.79	7.71
Inorganic substances										
ECC (electrical conductivity at 20°C)	mS/m	330		71	62	59	63	61	60	59
Bicarbonate	mg/l HCO_3	13		183	137	169	190	170	155	160
Fluoride	mg/l F	7		0.16		0.14		0.13		0.21
Bromide	mg/l Br	13	1	<	<	<	<	<	<	<
Chloride	mg/l Cl	327		90	73	66	89	95	97	96
Sulphate	mg/l SO_4	26		57	47	47	60	62	60	62
Sodium	mg/l Na	26		53.7	43.3	39.3	50.9	63.3	64.6	66.1
Potassium	mg/l K	13		5.2	3.7	4.1	4.7	4.8	4.6	5.5
Calcium	mg/l Ca	13		86	61	71	81	72	66	68
Magnesium	mg/l Mg	13		12.7	10.19	11.06	13.44	11.58	10.09	11.4
Total hardness	mmol/l	13		72.9	51.01	59.44	67.16	59.92	56.21	56.1
Total cyanide	µg/l CN	7	3	<		<		<		<
Eutrophying substances										
Ammonia	mg/l N	26		0.17	0.13	0.28	0.08	0.06	0.04	0.1
Kjeldahl nitrogen	mg/l N	23	0.1	0.45	0.37	0.4	0.25	0.43	0.65	0.45
Nitrate	mg/l N	22		3.76	3.1	3.41	3.62	2.51	2.32	2.47
Orthophosphate	mg/l P	26		0.085	0.083	0.076	0.077	0.057	0.074	0.106
Total phosphate	mg/l P	26		0.2	0.26	0.16	0.16	0.14	0.12	0.2
Heavy metals										
Iron	mg/l Fe	13		0.79	1.76	0.81	0.51	0.74	0.62	0.82
Manganese	mg/l Mn	13		0.05	0.07	0.05	0.04	0.06	0.04	0.06
Aluminium	µg/l Al	13		181	311	155	203	145	146	205
Antimony	µg/l Sb	12	0.01	0.34	0.16	<	0.18	0.06	<	
Arsenicum	µg/l As	26		1.3	2	1.4	1.85	1.63	1.8	2.25
Barium	µg/l Ba	13		88	68	76	79	66	66	73
Boron	mg/l B	13		0.09	0.05	0.06	0.08	0.08	0.07	0.09
Cadmium	µg/l Cd	26	0.05	0.05	0.19	0.06	<	<	0.05	0.09
Chromium	µg/l Cr	26		0.8	1.85	0.65	1	0.7	1.3	5.75
Copper	µg/l Cu	26		3.3	9.4	2.5	3.9	3.5	3.8	5.2
Mercury	µg/l Hg	26		0.019	0.042	0.012	0.015	0.016	0.015	0.046
Lead	µg/l Pb	26		1.9	8.2	2.7	2.2	2.1	2.3	5.1
Nickel	µg/l Ni	26	0.1	2.1	5.4	1.2	1.7	0.8	1.5	3.3
Selenium	µg/l Se	7	0.01	<		0.16		0.12		0.06
Zinc	µg/l Zn	26		7	40	17	14	7	8	24

n	number of observations during the year under review	min.	minimum
d.l.	detection limit	av.	average
10%, 50%, 90%	10%, 50%, 90% of the measurements are beneath the reported value	max.	maximum

Parameter	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**	min.	av.	max.	10%	50%	90%
General parameter											
Water discharge	2144	1805	1939	2390	2389	1510	2521	6224	1754	2238	3803
Temperature	22.4	19.7	15.4	9.9	9.4	4.7	14.7	23.9	6.7	15.1	21.8
Oxygen, dissolved	8.3	8.7	9.3	10.7	10.9	7.7	10.1	13.2	8.4	10	11.7
Oxygen saturation	76	80	86	92	92	70	89	123	77	91	97
Suspended matter	19.4	17.7	20.5	24.5	20.1	4	21.8	75	14	20	32
Residual ß-radioactivity (tot.-K40)	0.021	0.032	0.059	0.058	0.06	0.021	0.042	0.065	0.026	0.036	0.059
Tritium	7	6	2	3	3	2	4	7	2	4	6
pH-value	7.74	7.78	7.81	7.78	7.89	7.61	7.8	8.29	7.7	7.78	7.91
Inorganic substances											
ECC (electrical conductivity at 20°C)	54	65	64	64	63	46	62	86	54	62	69
Bicarbonate	155	160	160	123	185	115	159	190	130	160	183
Fluoride		0.17		0.17	0.16	0.13	0.16	0.21			
Bromide	<	<	<	<	<	<	<	<	<	<	<
Chloride	78	108	107	107	99	46	92	129	66	96	114
Sulphate	52	63	55	53	64	42	57	68	45	58	64
Sodium	48.5	70.9	66.2	58.3	53.3	32.7	56.9	71.4	46	57	70.4
Potassium	4.3	5.5	5.3	5.3	5	3.7	4.9	5.7	4.1	5	5.5
Calcium	63	67	64	71	73	61	70	86	63	68	74
Magnesium	9.8	11.12	10.9	11.02	11.68	9.8	11.23	13.44	10.09	11.12	11.74
Total hardness	53.6	55.68	52.7	59.68	61.32	51.01	58.88	72.9	52.7	56.8	62.56
Total cyanide		<		<	<	<	<	<			
Eutrophying substances											
Ammonia	0.05	0.04	0.04	0.07	0.11	0.03	0.09	0.47	0.03	0.06	0.14
Kjeldahl nitrogen	0.5	0.7	0.8	0.55		<	0.5	1	0.1	0.4	0.8
Nitrate	2.18	2.5	2.76	2.97		2.11	2.83	4.48	2.24	2.8	3.38
Orthophosphate	0.093	0.112	0.1	0.097	0.101	0.051	0.088	0.128	0.057	0.09	0.109
Total phosphate	0.17	0.18	0.19	0.17	0.17	0.12	0.18	0.39	0.13	0.16	0.21
Heavy metals											
Iron	0.63	0.48	1.01	1.42	0.47	0.47	0.88	1.76	0.48	0.79	1.26
Manganese	0.04	0.04	0.07	0.07	0.03	0.03	0.05	0.07	0.04	0.05	0.07
Aluminium	135	140	327	280	141	135	204	382	140	178	311
Antimony	0.38	<	<	<	<	<	0.1	0.38	<	<	0.18
Arsenicum	1.65	1.5	1.5	1.63	1.3	1.2	1.65	2.6	1.3	1.6	1.9
Barium	64	76	69	77	81	64	74	88	66	73	81
Boron	0.07	0.09	0.09	0.09	0.08	0.05	0.08	0.11	0.06	0.08	0.09
Cadmium	0.05	<	0.05	0.07	<	<	0.06	0.3	<	0.05	0.07
Chromium	0.9	0.45	0.95	0.93	1	0.3	1.32	7.6	0.6	0.9	1.7
Copper	3.6	3.4	4	4.1	3.1	1.8	4.1	13	3.2	3.6	4.7
Mercury	0.011	0.017	0.016	0.02	0.014	0.008	0.02	0.073	0.009	0.016	0.025
Lead	2	1.6	2.8	2.8	1.7	1.4	2.9	13	1.7	2.2	3.4
Nickel	2.2	1.6	2.5	2.6	1.7	<	2.2	7	0.7	2.1	3.1
Selenium		0.16		0.38	<	<	0.13	0.38			
Zinc	11	7	16	18	14	1	15	68	7	12	19

Parameter	unit	n	d.l.	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**June**	**July**
Organic substances, individual compounds										
Volatile chlorinated hydrocarbons										
dichloromethane	9	0.01	<	<	0.01	<	0.12	0.04		
1,2-dichloroethane	µg/l	13	0.01	0.04	0.02	0.02	0.02	0.02	0.02	0.02
1,2-dichloropropane	µg/l	13	0.01	<	<	<	0.02	0.01	<	<
cis 1,3 dichloropropene	µg/l	13	0.01	<	<	<	<	<	<	<
trans 1,3 dichloropropene	µg/l	13	0.01	<	<	<	<	<	<	<
trichloromethane	µg/l	13		0.02	0.03	0.02	1.8	0.27	0.02	0.02
1,1,1-trichloroethane	µg/l	13	0.01	<	<	<	<	<	<	<
trichloroethene	µg/l	13	0.01	0.01	<	0.01	0.02	0.01	<	0.01
1,2,3-trichloropropane	µg/l	13	0.01	<	<	<	<	<	<	<
tetrachloromethane	µg/l	13	0.01	<	<	<	<	<	<	<
tetrachloroethene	µg/l	13		0.04	0.03	0.02	0.05	0.02	0.02	0.02
bromodichloromethane	µg/l	13	0.01	<	<	<	<	<	<	<
dibromochloromethane	µg/l	13	0.01	<	<	<	<	<	<	<
tribromomethane	µg/l	13	0.01	<	<	<	<	<	0.01	<
Chlorophenoles										
2,3,4-trichlorophenol	µg/l	11	0.01	<	<	<	<	<	<	<
2,3,6-trichlorophenol	µg/l	11	0.01	<	<	<	<	<	<	<
2,4,5-trichlorophenol	µg/l	11	0.01	<	<	<	<	<	<	<
2,4,6-trichlorophenol	µg/l	11	0.01	<	<	<	<	<	<	<
3,4,5-trichlorophenol	µg/l	11	0.01	<	<	<	<	<	<	<
2,3,4,5-tetrachlorophenol	µg/l	11	0.01	<	<	<	<	<	<	<
pentachlorophenol	µg/l	11	0.01	<	<	<	<	<	<	<
Volatile aromatic hydrocarbons (MAC)										
methylbenzene	µg/l	13	0.01	<	<	<	<	<	<	<
benzene	µg/l	13	0.01	0.01	0.01	0.01	0.01	<	<	0.01
1,2-dimethylbenzene	µg/l	13	0.01	<	<	<	0.01	<	<	<
Meta + paraxylene	ug/l	13	0.01	<	<	0.01	0.02	<	<	0.01
ethylbenzene	µg/l	13	0.01	<	<	<	<	<	<	<
ethenylbenzene	µg/l	13	0.01	<	<	<	<	<	<	<
Polycyclic aromatic hydrocarbons (PAH)										
benzo(b)fluoranthene	µg/l	8		0.007		0.007		0.009	0.007	0.008
benzo(k)fluoranthene	µg/l	8	0.005	<		<		<	<	<
benzo(ghi)perylene	µg/l	8	0.005	0.006		<		0.006	<	0.005
benzo(a)pyrene	µg/l	8	0.005	0.006		<		0.007	0.005	0.007
fluoranthene	µg/l	8		0.015		0.009		0.014	0.014	0.017
indeno (1,2,3-cd)pyrene	µg/l	8	0.005	0.006		<		0.006	<	0.005
PAH, 6 of Borneff	µg/l	8		0.04		0.03		0.04	0.03	0.04
anthracene	µg/l	8	0.005	<		<		<	<	<
benzo(a)anthracene	µg/l	8	0.005	<		<		0.005	<	0.006
chrysene	µg/l	8	0.005	0.006		0.005		0.006	<	0.006
dibenzo(a,h)anthracene	µg/l	8	0.005	<		<		<	<	<
phenantrene	µg/l	8	0.05	<		<		<	<	<
naphtalene	µg/l	8	0.05	<		<		<	<	<
fluorene	µg/l	8	0.005	<		0.006		<	0.007	<
pyrene	µg/l	8		0.013		0.009		0.011	0.01	0.013

Parameter	Aug.	Sep.	Oct.	Nov.	Dec.	min.	av.	max.	10%	50%	90%
Organic substances, individual compounds											
Volatile chlorinated hydrocarbons											
dichloromethane				0.01	<	<	0.02	0.12			
1,2-dichloroethane	<	0.02	0.01	<	<	<	0.02	<	0.01	0.02	<
1,2-dichloropropane	<	0.06	<	<	<	<	0.01	0.06	<	<	0.01
cis 1,3 dichloropropene	<	<	<	<	<	<	<	<	<	<	<
trans 1,3 dichloropropene	<	<	<	<	<	<	<	<	<	<	<
trichloromethane	0.15	0.03	0.04	0.04	0.11	0.02	0.2	1.8	0.02	0.03	0.15
1,1,1-trichloroethane	<	<	<	<	<	<	<	<	<	<	<
trichloroethene	<	0.01	0.01	0.01	0.02	<	0.01	0.02	<	0.01	0.01
1,2,3-trichloropropane	<	<	<	<	<	<	<	<	<	<	<
tetrachloromethane	<	<	<	<	<	<	<	<	<	<	<
tetrachloroethene	0.03	0.03	0.02	0.03	0.04	0.02	0.03	0.05	0.02	0.03	0.04
bromodichloromethane	<	<	0.01	<	<	<	<	0.01	<	<	<
dibromochloromethane	<	<	<	<	<	<	<	<	<	<	<
tribromomethane	<	<	0.01	<	<	<	0.01	<	<	<	<
Chlorophenoles											
2,3,4-trichlorophenol	<	<	<	<		<	<	<	<	<	<
2,3,6-trichlorophenol	<	<	<	<		<	<	<	<	<	<
2,4,5-trichlorophenol	<	<	<	<		<	<	<	<	<	<
2,4,6-trichlorophenol	<	<	<	<		<	<	<	<	<	<
3,4,5-trichlorophenol	<	<	<	<		<	<	<	<	<	<
2,3,4,5-tetrachlorophenol	<	<	<	<		<	<	<	<	<	<
pentachlorophenol	<	<	<	<		<	<	<	<	<	<
Volatile aromatic hydrocarbons (MAC)											
methylbenzene	<	<	<	<	<	<	<	<	<	<	<
benzene	<	0.01	0.01	<	0.01	<	<	0.01	<	0.01	0.01
1,2-dimethylbenzene	<	<	<	<	<	<	<	0.01	<	<	<
Meta + paraxylene	<	<	<	<	<	<	<	0.02	<	<	0.01
ethylbenzene	<	<	<	<	<	<	<	<	<	<	<
ethenylbenzene	<	<	<	<	<	<	<	<	<	<	<
Polycyclic aromatic hydrocarbons (PAH)											
benzo(b)fluoranthene		0.011		0.013	0.007	0.007	0.009	0.013			
benzo(k)fluoranthene		<		0.005	<	<	<	0.005			
benzo(ghi)perylene		0.007		<	<	<	<	0.007			
benzo(a)pyrene		0.009		0.008	<	<	0.006	0.009			
fluoranthene		0.013		0.021	0.014	0.009	0.015	0.021			
indeno (1,2,3-cd)pyrene		0.006		0.006	<	<	<	0.006			
PAH, 6 of Borneff		0.05		0.06	0.03	0.03	0.04	0.06			
anthracene		<		<	<	<	<	<			
benzo(a)anthracene		0.009		0.008	<	<	<	0.009			
chrysene		0.01		0.009	0.006	<	0.006	0.01			
dibenzo(a,h)anthracene		<		0.006	<	<	<	0.006			
phenantrene		<		<	<	<	<	<			
naphtalene		<		<	<	<	<	<			
fluorene		0.007		<	0.005	<	<	0.007			
pyrene		0.02		0.018	0.011	0.009	0.013	0.02			

Parameter	unit	n	d.l.	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**June**	**July**
Complexing agents										
EDTA	µg/l	12	5	9	<	7	8	8	7	10
nitrilo triacetic acid (NTA)	µg/l	2	5							
Organic substances, sum and group parameters										
Dissolved organic carbon (DOC)	mg/l C	26		3	3.5	3.5	3	2.3	2.5	2
Colour intensity, Pt/Co-scale	mg/l Pt	7		9		9		14		10
Non-ionic + cationic detergents	mg/l	7	0.01	0.02		<		0.07		<
AOX (adsorbable organic halogens)	µg/l Cl	26		27	16.5	33	46	93	26.5	47
Cholinesterase inhibition	µg/l para	11	0.1	<	<	0.12	0.13	0.14	0.19	0.21
Algae biomass										
Chlorophyll-a	µg/l	25	1	1	2	4	15	24	9	3
Pheophytine	µg/l	25		2	2	2	6	15	6	3
Bacteria										
Thermotolerant bacteria, Coligroup	n/100 ml	24	10	795	1265	665	250	207	340	5125
Escherichia coli	n/100 ml	22		405	1255	815	290	132	250	755
Faecal streptococci	n/100 ml	24		320	515	152	55	23	25	280

Parameter	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**	min.	av.	max.	10%	50%	90%
Complexing agents											
EDTA	7	10	8	12	7	<	7.96	12	7	8	10
nitrilo triacetic acid (NTA)				<	<	<	<	<			
Organic substances, sum and group parameters											
Dissolved organic carbon (DOC)	3	2.5	3	3.7	3.5	2	3	4	2	3	4
Colour intensity, Pt/Co-scale		13		10	10	9	11	14			
Non-ionic + cationic detergents		0.04		0.03	0.02	<	0.03	0.07			
AOX (adsorbable organic halogens)	41.5	33	90.5	46.7	26	16	45.9	205	17	32.5	64
Cholinesterase inhibition	0.17	<	0.24	0.13		<	0.13	0.24	<	0.13	0.19
Algae biomass											
Chlorophyll-a	3	2	1	1	<	<	5	29	1	2	10
Pheophytine	3	3	2	2	2	1	4	15	1	2	7
Bacteria											
Thermotolerant bacteria, Coligroup	2975	655	745	1963	3400	<	1472	8200	220	735	3300
Escherichia coli	570	700	575	1790		10	803	3000	140	455	1730
Faecal streptococci	14	48	97	343	780	3	203	780	10	83	500

The quality of the Lek water at Nieuwegein in 1999

Supplement 3A

(monthly averages and index numbers)

Parameter	unit	n	d.l.	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**June**	**July**
General parameter										
Temperature	°C	254		6.8	5.4	8.2	11.6	16	18.4	21.3
Oxygen, dissolved	mg/l O_2	52		10.2	11.6	10.7	10.3	9.3	8.2	6.7
Oxygen saturation	%	52		83	91	90	91	86	76	61
Suspended matter	mg/l	250		33.3	25.5	27.1	24.1	30.8	42	29.5
Residual ß-radioactivity (tot.-K40)	Bq/l	6	0.1		<		<		<	
Odour dilution factor		12		18	16	7	12	25	10	10
pH-value	pH	254		8.08	8.06	8.07	8.17	8.32	8.1	8.04
Inorganic substances										
ECC (electrical conductivity at 20°C)	mS/m	52		67	67	51	59	57	52	57
Bicarbonate	mg/l HCO_3	53		169	166	157	170	177	174	169
Fluoride	mg/l F	8			0.13		0.11		0.11	
Bromide	mg/l Br	12		0.1	0.2	0.1	0.1	0.1	0.1	0.2
Chloride	mg/l Cl	364		96	95	63	77	70	65	82
Sulphate	mg/l SO_4	13		61	62	49	51	56	44	54
Sodium	mg/l Na	13		54	57	35	37	41	34	47
Potassium	mg/l K	13		4.6	5.8	3.2	4	4.2	3.5	4.4
Calcium	mg/l Ca	13		78	79	70	70	70	65	66
Magnesium	mg/l Mg	13		12	12	10.5	11	10.5	9.5	10
Total hardness	mmol/l	13		66	67	59.5	59	59.5	55.5	56
Total cyanide	µg/l CN	6	2		<		<		<	
Eutrophying substances										
Ammonia	mg/l N	13	0.02	0.12	0.22	0.11	0.04	<	0.06	0.06
Kjeldahl nitrogen	mg/l N	13		0.55	0.68	0.67	0.56	0.55	0.63	0.59
Nitrate	mg/l N	13		4.2	4.3	3.3	3.2	2.3	1.8	1.8
Orthophosphate	mg/l P	13		0.12	0.11	0.093	0.088	0.07	0.011	0.085
Total phosphate	mg/l P	13		0.15	0.17	0.11	0.13	0.13	0.12	0.2
Heavy metals										
Iron	mg/l Fe	246		1.38	1.18	1.39	0.98	1.05	1.39	0.99
Manganese	mg/l Mn	13		0.07	0.06	0.05	0.05	0.09	0.08	0.12
Aluminium (after filtration)	µg/l Al	12		20	19	42	18	56		41
Arsenicum	µg/l As	13		1	1.1	1.3	1.1	1.5	1.6	1.8
Barium	µg/l Ba	13		96	99	94	88	138	56	102
Beryllium	µg/l Be	13		0.04	0.07	0.1	0.11	0.12	0.09	0.14
Boron	mg/l B	13		0.07	0.08	0.05	0.06	0.06	0.05	0.09
Cadmium	µg/l Cd	13		0.08	0.08	0.07	0.08	0.12	0.09	0.12
Chromium	µg/l Cr	13		5.6	4.3	3.2	4.9	5.6	5.2	4.7
Copper	µg/l Cu	13		3.9	3.4	4	3.5	5	5.3	5
Mercury	µg/l Hg	13	0.05	<	<	<	<	<	<	<
Lead	µg/l Pb	13		4.3	4.8	3.2	3.6	5	3.3	6.2
Nickel	µg/l Ni	13		3.2	2.9	2.1	2.3	3	2.6	3.1
Selenium	µg/l Se	13	1	<	<	<	2.5	<	<	<
Zinc	µg/l Zn	13		19	16	12	20	40	16	28

n	number of observations during the year under review	min.	minimum
d.l.	detection limit	av.	average
10%, 50%, 90%	10%, 50%, 90% of the measurements are beneath the reported value	max.	maximum

Parameter	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**	min.	av.	max.	10%	50%	90%
General parameter											
Temperature	20,9	19,6	13,3	9	6,3	4	13,1	23,8	5,8	11,6	20,8
Oxygen, dissolved	6.3	6.8	8.1	11.3	9.9	5.6	9.1	14.7	6.2	9.4	11.1
Oxygen saturation	58	63	73	97	80	51	79	122	58	81	93
Suspended matter	25.8	33.9	32.5	29	33.4	6.2	30.6	151.4	18	28	45
Residual ß-radioactivity (tot.-K40)	<		<		<	<	<	<			
Odour dilution factor	8	12	10	8	18	7	13	25	8	11	18
pH-value	7.97	7.87	8.02	8.11	8.08	7.71	8.07	8.55	7.9	8.06	8.22
Inorganic substances											
ECC (electrical conductivity at 20°C)	64	65	69	75	67	46	62	77	51	63	74
Bicarbonate	166	166	169	178	164	137	168	187	153	170	176
Fluoride	0.14		0.16	0.15	0.16	0.11	0.14	0.16			
Bromide	0.2	0.2	0.2	0.2	0.1	0.1	0.15	0.2	0.1	0.15	0.2
Chloride	98	103	105	125	107	47	90	138	61	93	118
Sulphate	73	56	68	66	52	41	57	73	44	56	66
Sodium	64.5	57	77	71.5	52	34	52.2	77	35	54	64.5
Potassium	5.3	4.8	5.8	5.6	4.8	3.2	4.7	5.8	3.5	4.6	5.6
Calcium	67	67	69	73	70	62	70	79	65	70	77
Magnesium	11	11	12	11	10.5	9	10.88	12	9.5	11	12
Total hardness	56	56	57	62	59	53	59.35	67	55.5	59	65
Total cyanide	<		<		<	<	<	<			
Eutrophying substances											
Ammonia	0.15	0.11	0.07	0.07	0.17	<	0.1	0.22	0.04	0.11	0.15
Kjeldahl nitrogen	0.6	0.54	0.55	0.48	0.65	0.48	0.59	0.68	0.54	0.59	0.66
Nitrate	1.6	2.2	2.6	2.7	3.15	1.6	2.79	4.3	1.8	2.7	3.3
Orthophosphate	0.083	0.11	0.12	0.18	0.095	0.011	0.097	0.18	0.07	0.093	0.12
Total phosphate	0.14	0.18	0.28	0.15	0.16	0.11	0.16	0.28	0.12	0.15	0.18
Heavy metals											
Iron	0.97	1.36	1.25	1.29	1.2	0.09	1.21	5.2	0.74	1.1	1.75
Manganese	0.08	0.1	0.12	0.06	0.07	0.05	0.08	0.12	0.05	0.07	0.1
Aluminium (after filtration)	12	8.6	35	35	46.5	8.6	31.63	72	12	28	42
Arsenicum	2.3	2.2	2.8	1.8	1.65	1	1.68	2.8	1.1	1.6	2.2
Barium	110	121	142	117	103	56	105	142	88	102	121
Beryllium	0.08	0.14	0.19	0.08	0.14	0.04	0.11	0.19	0.07	0.1	0.14
Boron	0.11	0.09	0.12	0.1	0.07	0.05	0.08	0.12	0.05	0.08	0.1
Cadmium	0.08	0.1	0.21	0.09	0.13	0.07	0.11	0.21	0.08	0.09	0.12
Chromium	5.9	6.2	9.3	3.9	4.35	2.8	5.19	9.3	3.2	5.2	5.9
Copper	4.2	6.1	8.2	4.6	4.7	3.4	4.8	8.2	3.5	4.6	5.3
Mercury	<	<	0.06	<	<	<	<	0.06	<	<	<
Lead	3.7	7	9.3	4.1	4.6	3.2	4.9	9.3	3.3	4.5	6.2
Nickel	3.5	4.1	4.8	2.8	3.3	2.1	3.1	4.8	2.3	3	3.6
Selenium	1	<	<	<	<	<	<	2.5	<	<	<
Zinc	19	22	38	18	23	12	23	40	16	19	29

Parameter	unit	n	d.l.	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**June**	**July**
Organic substances, individual compounds										
Volatile chlorinated hydrocarbons										
1,2-dichloroethane	µg/l	10	0.1				<	<	<	<
1,2-dichloropropane	µg/l	13	0.1	<	<	<	<	<	<	<
cis 1,3 dichloropropene	µg/l	13	0.1	<	<	<	<	<	<	<
trans 1,3 dichloropropene	µg/l	13	0.1	<	<	<	<	<	<	<
trichloromethane	µg/l	13	0.1	<	<	<	<	<	<	<
1,1,1-trichloroethane	µg/l	13	0.1	<	<	<	<	<	<	<
trichloroethene	µg/l	13	0.1	<	<	<	<	<	<	<
1,2,3-trichloropropane	µg/l	13	0.1	<	<	<	<	<	<	<
tetrachloromethane	µg/l	13	0.1	<	<	<	<	<	<	<
tetrachloroethane	µg/l	13	0.1	<	<	<	<	<	<	<
tetrachloroethene	µg/l	13	0.1	<	<	<	<	<	<	<
bromochloromethane	µg/l	13	0.1	<	<	<	<	<	<	<
bromodichloromethane	µg/l	13	0.1	<	<	<	<	<	<	<
dibromochloromethane	µg/l	13	0.1	<	<	<	<	<	<	<
tribromomethane	µg/l	13	0.1	<	<	<	<	<	<	<
Volatile aromatic hydrocarbons (MAC)										
chlorobenzene	µg/l	13	0.1	<	<	<	<	<	<	<
2-methylaniline	µg/l	7	0.03	<	0.05	<	<			
methylbenzene	µg/l	13	0.1	<	<	<	<	<	<	<
benzene	µg/l	13	0.1	<	<	<	<	<	<	<
1,2-dimethylbenzene	µg/l	13	0.1	<	<	<	<	<	<	<
ethylbenzene	µg/l	13	0.1	<	<	<	<	<	<	<
ethenylbenzene	µg/l	13	0.1	<	<	<	<	<	<	<
Polycyclic aromatic hydrocarbons (PAH)										
benzo(b)fluoranthene	µg/l	12		0.02	0.02	0.01	0.02	0.01	0.02	0.01
benzo(k)fluoranthene	µg/l	12	0.01	<	0.01	<	<	<	0.01	<
benzo(ghi)perylene	µg/l	12	0.01	<	0.01	<	0.01	<	0.01	<
benzo(a)pyrene	µg/l	12	0.01	0.01	0.02	<	0.02	0.01	0.02	<
fluoranthene	µg/l	12		0.04	0.05	0.03	0.04	0.04	0.05	0.03
indeno (1,2,3-cd)pyrene	µg/l	12	0.01	<	0.01	<	0.01	<	0.01	<
PAH, 6 of Borneff	µg/l	12		0.08	0.12	0.06	0.1	0.07	0.12	0.06
anthracene	µg/l	12	0.01	<	<	<	<	<	<	<
benzo(a)anthracene	µg/l	12		0.02	0.02	0.01	0.02	0.01	0.02	0.01
chrysene	µg/l	12		0.02	0.02	0.01	0.02	0.01	0.02	0.02
dibenzo(a,h)anthracene	µg/l	12	0.01	<	<	<	<	<	<	<
phenantrene	µg/l	12		0.02	0.03	0.02	0.02	0.02	0.03	0.02
naphtalene	µg/l	12	0.05	<	<	<	<	<	<	<
fluorene	µg/l	12	0.01	<	<	<	<	<	0.01	<
pyrene	µg/l	12		0.03	0.04	0.02	0.03	0.03	0.04	0.02
Complexing agents										
EDTA	µg/l	4	2			<			<	

Parameter	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**	min.	av.	max.	10%	50%	90%
Organic substances, individual compounds											
Volatile chlorinated hydrocarbons											
1,2-dichloroethane	<	<	<	<	<	<	<	<	<	<	<
1,2-dichloropropane	<	<	<	<	<	<	<	<	<	<	<
cis 1,3 dichloropropene	<	<	<	<	<	<	<	<	<	<	<
trans 1,3 dichloropropene	<	<	<	<	<	<	<	<	<	<	<
trichloromethane	<	<	<	<	<	<	<	<	<	<	<
1,1,1-trichloroethane	<	<	<	<	<	<	<	<	<	<	<
trichloroethene	<	<	<	<	<	<	<	<	<	<	<
1,2,3-trichloropropane	<	<	<	<	<	<	<	<	<	<	<
tetrachloromethane	<	<	<	<	<	<	<	<	<	<	<
tetrachloroethane	<	<	<	<	<	<	<	<	<	<	<
tetrachloroethene	<	<	<	<	<	<	<	<	<	<	<
bromochloromethane	<	<	<	<	<	<	<	<	<	<	<
bromodichloromethane	<	<	<	<	<	<	<	<	<	<	<
dibromochloromethane	<	<	<	<	<	<	<	<	<	<	<
tribromomethane	<	<	<	<	<	<	<	<	<	<	<
Volatile aromatic hydrocarbons (MAC)											
chlorobenzene	<	<	<	<	<	<	<	<	<	<	<
2-methylaniline				<	0.04	<	<	0.06			
methylbenzene	<	<	<	<	<	<	<	<	<	<	<
benzene	<	<	<	<	<	<	<	<	<	<	<
1,2-dimethylbenzene	<	<	<	<	<	<	<	<	<	<	<
ethylbenzene	<	<	<	<	<	<	<	<	<	<	<
ethenylbenzene	<	<	<	<	<	<	<	<	<	<	<
Polycyclic aromatic hydrocarbons (PAH)											
benzo(b)fluoranthene	0.01	0.02	0.03	0.02	0.02	0.01	0.017	0.03	0.01	0.02	0.02
benzo(k)fluoranthene	<	<	0.02	0.01	0.01	<	<	0.02	<	<	0.01
benzo(ghi)perylene	<	0.01	0.02	0.01	0.01	<	<	0.02	<	0.01	0.01
benzo(a)pyrene	<	0.02	0.03	0.02	0.02	<	0.015	0.03	<	0.02	0.02
fluoranthene	0.03	0.05	0.07	0.04	0.04	0.03	0.043	0.07	0.03	0.04	0.05
indeno (1,2,3-cd)pyrene	<	0.01	0.02	<	0.02	<	<	0.02	<	0.01	0.01
PAH, 6 of Borneff	0.06	0.11	0.19	0.1	0.12	0.06	0.1	0.19	0.06	0.1	0.12
anthracene	<	<	0.02	<	<	<	<	0.02	<	<	<
benzo(a)anthracene	0.01	0.02	0.02	0.01	0.02	0.01	0.016	0.02	0.01	0.02	0.02
chrysene	0.01	0.02	0.03	0.02	0.02	0.01	0.018	0.03	0.01	0.02	0.02
dibenzo(a,h)anthracene	<	<	<	<	<	<	<	<	<	<	<
phenantrene	0.02	0.02	0.04	0.02	0.02	0.02	0.023	0.04	0.02	0.02	0.03
naphtalene	<	<	<	<	<	<	<	<	<	<	<
fluorene	<	<	0.01	<	<	<	<	0.01	<	<	<
pyrene	0.02	0.04	0.05	0.04	0.04	0.02	0.033	0.05	0.02	0.035	0.04
Complexing agents											
EDTA		4.5			11	<	4.37	11			

Parameter	unit	n	d.l.	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**June**	**July**
Organic substances, sum and group parameters										
COD (Chemical oxygen demand)	mg/l O_2	13		10	12	15	11	11	12	14
COD (filtered)	mg/l O_2	13		8	10	9	7	7	6	14
Colour intensity, Pt/Co-scale	mg/l Pt	13		10	11	9	9	7	17	10
Non-ionic + cationic detergents	mg/l	13	0.02	0.03	0.04	0.04	0.04	0.05	<	0.06
Mineral oil, GC-method	mg/l	4	50			<				<
AOX (adsorbable organic halogens)	µg/l Cl	13		13	10	8	9	10	8	11
Cholinesterase inhibition	µg/l para	13	0.1	0.1	0.14	<	0.13	0.11	0.2	21
Algae biomass										
Silicate	mg/l Si	13		3.57	3.26	2.84	2.28	1.08	1.43	0.57
Chlorophyll-a	µg/l	34		2	3	4	11	25	12	8
Pheophytine	µg/l	34		2	2	2	6	15	14	12
Bacteria										
Thermotolerant bacteria, Coligroup	n/100 ml	26		114	270	210	81	54	136	65
Escherichia coli	n/100 ml	26		200	295	265	118	95	89	160
Faecal streptococci	n/100 ml	26		57	82	51	30	7	14	22

Parameter	Aug.	Sep.	Oct.	Nov.	Dec.	min.	av.	max.	10%	50%	90%
Organic substances, sum and group parameters											
COD (Chemical oxygen demand)	10	12	14	10	12	10	12	15	10	12	14
COD (filtered)	10	10	10	10	11	6	9	14	7	10	10
Colour intensity, Pt/Co-scale	12	6	10	12	13	6	11	17	7	10	12
Non-ionic + cationic detergents	0.06	0.07	0.03	0.06	0.05	<	0.05	0.07	0.03	0.04	0.06
Mineral oil, GC-method		<			<	<	<	<			
AOX (adsorbable organic halogens)	14	16	20	26	24	8	14.8	30	8	13	20
Cholinesterase inhibition	0.63	3.6	0.33	0.5	0.25	<	2.1	21	0.1	0.2	0.63
Algae biomass											
Silicate	0.89	1.99	2.16	2.73	3.01	0.57	2.22	3.57	0.89	2.28	3.06
Chlorophyll-a	3	3	2	3	1	0	11	45	2	10	25
Pheophytine	8	6	8	3	4	1	9	23	2	8	17
Bacteria											
Thermotolerant bacteria, Coligroup	129	112	180	85	733	33	200	980	65	125	300
Escherichia coli	285	305	200	75	483	50	220	900	50	195	320
Faecal streptococci	71	97	84	50	146	6	61	300	8	48	110

The quality of the Lek water at Nieuwegein in 2000

Supplement 3B

(monthly averages and index numbers)

Parameter	unit	n	d.l.	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**June**	**July**
General parameter										
Temperature	°C	34		4.9	6.1	9.1	11.8	18.7	19.3	18.5
Oxygen, dissolved	mg/l O_2	52		10.1	11.6	10.4	10.4	8.9	8	8.3
Oxygen saturation	%	14		91	91	91	96	80	76	77
Suspended matter	mg/l	57		34.8	34.5	32.4	26.3	24.8	35.5	28.3
Residual ß-radioactivity (tot.-K40)	Bq/l	6	0.02	<		<		<		<
Odour dilution factor		12		35	25	12	25	20	25	12
pH-value	pH	13		8.02	7.84	7.97	8.12	8.08	7.89	7.95
Inorganic substances										
ECC (electrical conductivity at 20°C)	mS/m	12		69	52	59		67	59	71
Bicarbonate	mg/l HCO_3	52		159	164	156	181	175	162	157
Fluoride	mg/l F	6		0.15		0.13		0.14		0.13
Bromide	mg/l Br	11		0.2	0.1	0.1	0.2	0.2	0.1	193
Chloride	mg/l Cl	48		117	69	68	113	96	92	124
Sulphate	mg/l SO_4	12		61	45	51	60	60	54	63
Sodium	mg/l Na	13		60	35.5	42.5	54	56	44	70
Potassium	mg/l K	13		5.1	3.8	4.1	4.8	4.6	3.9	5.2
Calcium	mg/l Ca	13		80	61	70	75	71	66	67
Magnesium	mg/l Mg	13		11	10	10	12	11.5	10	11
Total hardness	mmol/l	13		69	51	60	63	59.5	56	56
Total cyanide	µg/l CN	6	2	<		<		<		<
Eutrophying substances										
Ammonia	mg/l N	12	0.01	0.13	0.1	0.06	0.04	0.07	0.07	0.08
Kjeldahl nitrogen	mg/l N	13		0.62	0.52	0.48	0.45	0.69	0.49	0.59
Nitrate	mg/l N	12		3.6	3.4	3.5	3.3	2	2.3	2.4
Orthophosphate	mg/l P	11		0.1	0.08	0.07	0.05	0.06	0.09	0.08
Total phosphate	mg/l P	11		0.11	0.1	0.13	0.09	0.14	0.19	0.14
Heavy metals										
Iron	mg/l Fe	49		1.74	1.42	1.37	1.03	0.94	1.26	1.07
Manganese	mg/l Mn	12		0.09	0.07	0.08	0.06	0.09	0.09	0.06
Aluminium (after filtration)	µg/l Al	1		16						
Arsenicum	µg/l As	12	1	2	2	1	2	2	2	1
Barium	µg/l Ba	12		104	67	101	94	111	103	119
Beryllium	µg/l Be	12		0.18	0.11	0.16	0.1	0.12	0.12	0.11
Boron	mg/l B	12		0.08	0.05	0.06	0.08	0.07	0.06	0.09
Cadmium	µg/l Cd	13	0.05	0.13	<	0.14	0.09	0.15	0.12	0.13
Chromium	µg/l Cr	12		1.5	5.4	1.8	2.1	5.4	3.8	7.6
Copper	µg/l Cu	12		4.2	4.3	4.6	4.5	5.5	4.4	4.7
Mercury	µg/l Hg	12	0.02	0.04	0.03	0.05	<	0.03	0.04	0.04
Lead	µg/l Pb	12		4	4	5.2	4	4.8	5.1	6.1
Nickel	µg/l Ni	12		3.2	3.2	2.6	2.2	2.8	3.3	3.3
Selenium	µg/l Se	12	1	<	1	<	<	<	<	<
Zinc	µg/l Zn	12		17	14	12	14	15	20	15

n	number of observations during the year under review	min.	minimum
d.l.	detection limit	av.	average
10%, 50%, 90%	10%, 50%, 90% of the measurements are beneath the reported value	max.	maximum

Parameter	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**	min.	av.	max.	10%	50%	90%
General parameter											
Temperature		19.3		10	4.2	4.2	16.7	21.7	8.8	18.4	20.7
Oxygen, dissolved	8	8.3	9.2	9.8	11.1	7.8	9.5	12	8	9.2	11.4
Oxygen saturation		77		91	88	76	85	96	76	88	91
Suspended matter	22.4	31.7	31.5	45.2	44.3	7.4	33.3	80	22	31	49
Residual ß-radioactivity (tot.-K40)		<		<		<	0.085	<			
Odour dilution factor	14	10	8	14		7	18	35	8	17	25
pH-value	7.86	8	8.01	8.22	8.24	7.84	8.03	8.24	7.86	8.01	8.22
Inorganic substances											
ECC (electrical conductivity at 20°C)	55	64	65	68	64	52	64	71	55	65	69
Bicarbonate	153	158	165	172	174	132	165	191	149	166	181
Fluoride		0.14		0.15		0.13	0.14	0.15			
Bromide	133	0.2	0.2	0.2		0.1	29.773	193	0.1	0.2	0.2
Chloride	79	103	101	109	94	68	95	124	85	95	106
Sulphate	49	58	55	57		45	56	63	49	57	60
Sodium	43	58	58	55	48	35.5	52.2	70	42.5	54	60
Potassium	4.2	5	5.3	4.9	4.6	3.8	4.7	5.3	3.9	4.8	5.1
Calcium	60	65	65	74	73	60	69	80	61	70	75
Magnesium	10	10.5	10.5	11.25	12	10	10.85	12	10	11	11.5
Total hardness	50	54.5	54.5	62.75	61	50	58.46	69	51	59.5	63
Total cyanide		<		<		<	<	<			
Eutrophying substances											
Ammonia	0.02	0.06	<	0.06		<	0.06	0.13	0.02	0.06	0.08
Kjeldahl nitrogen	0.38	0.53	0.42	0.6	0.53	0.38	0.53	0.74	0.42	0.52	0.62
Nitrate	2.3	2.25	2.5	2.95		2	2.79	3.6	2.25	2.7	3.4
Orthophosphate	0.09	0.11	0.1	0.09		0.05	0.084	0.11	0.06	0.09	0.1
Total phosphate	0.16	0.15	0.14	0.14		0.09	0.14	0.19	0.1	0.14	0.15
Heavy metals											
Iron	0.94	1.28	1.22	1.64	1.78	0.36	1.29	2.75	0.78	1.25	1.75
Manganese	0.06	0.08	0.05	0.09		0.05	0.08	0.09	0.06	0.08	0.09
Aluminium (after filtration)						16	16	16			
Arsenicum	<	2	1	2.5		<	1.71	3	1	2	2
Barium	86	126	119	133		67	108	149	86	108	119
Beryllium	0.13	0.18	0.09	0.16		0.09	0.13	0.2	0.1	0.12	0.18
Boron	0.06	0.07	0.09	0.07		0.05	0.07	0.09	0.06	0.07	0.08
Cadmium	0.09	0.16	0.09	0.13	0.1	<	0.11	0.16	0.09	0.13	0.14
Chromium	4.2	7	4.9	7.35		1.5	4.87	8	1.8	5.15	7
Copper	4.3	6.3	5.4	7.4		4.2	5.3	8	4.3	4.6	6.3
Mercury	<	0.06	0.02	0.085		<	0.042	0.11	<	0.04	0.06
Lead	4.1	7.2	4.1	8.1		4	5.4	11	4	4.9	6.1
Nickel	2.5	3.7	3.4	3.9		2.2	3.2	4.2	2.5	3.3	3.7
Selenium	<	<	<	<		<	<	1	<	<	<
Zinc	4	11	14	28		4	16	35	11	14	20

Parameter	unit	n	d.l.	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**June**	**July**
Organic substances, individual compounds										
Volatile chlorinated hydrocarbons										
1,2-dichloropropane	µg/l	11	0.1	<	<		<	<	<	<
cis 1,3 dichloropropene	µg/l	11	0.1		<	<	<	<	<	<
trans 1,3 dichloropropene	µg/l	11	0.1		<	<	<	<	<	<
trichloromethane	µg/l	12	0.1	<	<	<	<	<	<	<
1,1,1-trichloroethane	µg/l	11	0.1		<	<	<	<	<	<
trichloroethene	µg/l	12	0.1	<	<	<	<	<	<	<
1,2,3-trichloropropane	µg/l	12	0.1	<	<	<	<	<	<	<
tetrachloromethane	µg/l	12	0.1	<	<	<	<	<	<	<
tetrachloroethene	µg/l	12	0.1	<	<	<	<	<	<	<
bromodichloromethane	µg/l	12	0.1	<	<	<	<	<	<	<
dibromochloromethane	µg/l	12	0.1	<	<	<	<	<	<	<
tribromomethane	µg/l	12	0.1	<	<	<	<	<	<	<
Volatile aromatic hydrocarbons (MAC)										
methylbenzene	µg/l	12	0.1	<	<	<	<	<	<	<
benzene	µg/l	12	0.1	<	<	<	<	<	<	<
1,2-dimethylbenzene	µg/l	12	0.1	<	<	<	<	<	<	<
ethylbenzene	µg/l	12	0.1	<	<	<	<	<	<	<
ethenylbenzene	µg/l	12	0.1	<	<	<	<	<	<	<
Polycyclic aromatic hydrocarbons (PAH)										
benzo(b)fluoranthene	µg/l	11	0.01	0.03	<	0.03	0.03	<	0.05	0.02
benzo(k)fluoranthene	µg/l	11	0.01	0.02	<	0.01	0.01	0.01	0.02	<
benzo(ghi)perylene	µg/l	11	0.01	0.02	<	0.02	0.02	0.02	0.02	0.01
benzo(a)pyrene	µg/l	11	0.01	0.03	<	0.02	0.02	0.02	0.03	0.01
fluoranthene	µg/l	11	0.01	0.1	<	0.06	0.04	<	0.07	0.04
indeno (1,2,3-cd)pyrene	µg/l	11	0.01	<	<	<	<	<	0.03	<
PAH, 6 of Borneff	µg/l	11		0.2	0.03	0.14	0.12	0.06	0.22	0.09
anthracene	µg/l	11	0.01	0.03	<	<	0.01	<	0.01	<
benzo(a)anthracene	µg/l	11	0.01	0.04	<	0.03	0.02	0.02	0.02	0.01
chrysene	µg/l	11	0.01	0.03	<	0.02	0.02	0.02	0.03	0.01
dibenzo(a,h)anthracene	µg/l	11	0.01	<	<	<	0.01	<	<	<
phenantrene	µg/l	11	0.01	0.09	<	0.03	0.02	<	0.04	0.02
naphtalene	µg/l	11	0.05	<	<	<	<	<	<	<
fluorene	µg/l	11	0.01	0.02	<	<	0.01	<	0.01	<
pyrene	µg/l	11	0.01	0.09	<	0.04	0.03	<	0.05	0.03
Organic substances, sum and group parameters										
COD (Chemical oxygen demand)	mg/l O_2	1		14						
COD (filtered)	mg/l O_2	12	2	12	10	7	10	8	9	<
Colour intensity, Pt/Co-scale	mg/l Pt	12		10	12	9	10	10	9	10
Non-ionic + cationic detergents	mg/l	12	0.02	0.04	0.08	0.12	0.04	0.02	<	<
AOX (adsorbable organic halogens)	µg/l Cl	11		24	20		23	23	20	19
Cholinesterase inhibition	µg/l para	12	0.1	0.43	0.14	0.13	0.13	<	<	0.11

Parameter	Aug.	Sep.	Oct.	Nov.	Dec.	min.	av.	max.	10%	50%	90%
Organic substances, individual compounds											
Volatile chlorinated hydrocarbons											
1,2-dichloropropane	<	<	<	<		<	<	<	<	<	<
cis 1,3 dichloropropene	<	<	<	<		<	<	<	<	<	<
trans 1,3 dichloropropene	<	<	<	<		<	<	<	<	<	<
trichloromethane	<	<	<	<		<	<	<	<	<	<
1,1,1-trichloroethane	<	<	<	<		<	<	<	<	<	<
trichloroethene	<	<	<	<		<	<	<	<	<	<
1,2,3-trichloropropane	<	<	<	<		<	<	<	<	<	<
tetrachloromethane	<	<	<	<		<	<	<	<	<	<
tetrachloroethene	<	<	<	<		<	<	<	<	<	<
bromodichloromethane	<	<	<	<		<	<	<	<	<	<
dibromochloromethane	<	<	<	<		<	<	<	<	<	<
tribromomethane	<	<	<	<		<	<	<	<	<	<
Volatile aromatic hydrocarbons (MAC)											
methylbenzene	<	<	<	<		<	<	<	<	<	<
benzene	<	<	<	<		<	<	<	<	<	<
1,2-dimethylbenzene	<	<	<	<		<	<	<	<	<	<
ethylbenzene	<	<	<	<		<	<	<	<	<	<
ethenylbenzene	<	<	<	<		<	<	<	<	<	<
Polycyclic aromatic hydrocarbons (PAH)											
benzo(b)fluoranthene	0.02	0.04	<	0.07		<	0.028	0.07	<	0.03	0.04
benzo(k)fluoranthene	0.01	0.01	<	0.03		<	0.012	0.03	<	0.01	0.02
benzo(ghi)perylene	0.01	0.02	<	0.04		<	0.017	0.04	<	0.02	0.02
benzo(a)pyrene	0.01	0.02	0.01	0.05		<	0.02	0.05	0.01	0.02	0.03
fluoranthene	0.03	0.06	0.03	0.16		<	0.055	0.16	<	0.04	0.07
indeno (1,2,3-cd)pyrene	<	<	<	<		<	<	0.03	<	<	<
PAH, 6 of Borneff	0.08	0.15	0.06	0.35		0.03	0.14	0.35	0.06	0.12	0.2
anthracene	0.01	0.01	<	0.03		<	0.011	0.03	<	0.01	0.01
benzo(a)anthracene	0.01	0.02	0.01	0.05		<	0.021	0.05	0.01	0.02	0.03
chrysene	0.01	0.02	0.01	0.07		<	0.022	0.07	0.01	0.02	0.03
dibenzo(a,h)anthracene	<	<	<	<		<	<	0.01	<	<	<
phenantrene	0.01	0.03	<	0.08		<	0.03	0.09	<	0.02	0.04
naphtalene	<	<	<	<		<	<	<	<	<	<
fluorene	0.01	0.01	<	0.02		<	<	0.02	<	0.01	0.01
pyrene	0.02	0.04	0.02	0.12		<	0.041	0.12	<	0.03	0.05
Organic substances, sum and group parameters											
COD (Chemical oxygen demand)						14	14	14			
COD (filtered)	22	10	8	7		<	9	22	4	9	10
Colour intensity, Pt/Co-scale	10	11	13	12		9	11	13	9	10	12
Non-ionic + cationic detergents	<	0.02	0.14	0.03		<	0.05	0.14	<	0.03	0.08
AOX (adsorbable organic halogens)	21		34	26		19	24.5	35	20	23	30
Cholinesterase inhibition	4.1	<	0.85	0.58		<	0.6	4.1	<	0.13	0.66

Parameter	unit	n	d.l.	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**June**	**July**
Algae biomass										
Silicate	mg/l Si	11		3.58	3.2		2.18	0.45	1.99	1.87
Chlorophyll-a	µg/l	13		2	1	3	4	6	4	3
Pheophytine	µg/l	13		3	4	3	5	14	8	5
Bacteria										
Thermotolerant bacteria, Coligroup	n/100 ml	23		285	330	185	59	105	120	175
Escherichia coli	n/100 ml	24		280	365	235	35	195	80	215
Faecal streptococci	n/100 ml	25		105	200	62	44	30	71	76

Parameter	Aug.	Sep.	Oct.	Nov.	Dec.	min.	av.	max.	10%	50%	90%
Algae biomass											
Silicate	2.37	2.09	2.61	3.05		0.45	2.4	3.58	1.87	2.37	3.2
Chlorophyll-a	1	3	1	1	1	1	2	6	1	2	4
Pheophytine	4	5	3	5	2	2	5	14	3	4	5
Bacteria											
Thermotolerant bacteria, Coligroup	155	185	330	340	430	30	216	530	78	180	410
Escherichia coli	295	300	395	333	360	20	261	590	56	285	420
Faecal streptococci	103	121	235	81	93	8	98	320	14	96	150

The quality of the IJsselmeer water at Andijk in 1999

Supplement 4A

(monthly averages and index numbers)

Parameter	unit	n	d.l.	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**June**	**July**
General parameter										
TTemperature	°C	104		4.4	3.3	5.4	10.6	14.7	16.6	20.1
Oxygen, dissolved	mg/l O_2	52		11.9	12	11.6	10.3	9.6	9.1	8.9
Oxygen saturation	%	52		92	89	92	90	88	84	83
Suspended matter	mg/l	52		17.4	24.3	25.7	15.3	21.2	17.9	19.8
Residual ß-radioactivity (tot.-K40)	Bq/l	6	0.1		<		<		<	
Tritium	Bq/l	6	10		<		<		<	
pH-value	pH	52		8.27	8.3	8.36	8.65	8.74	8.77	9
Inorganic substances										
ECC (electrical conductivity at 20°C)	mS/m	104		63	68	64	56	57	53	49
Bicarbonate	mg/l HCO_3	52		158	177	166	158	147	127	92
Fluoride	mg/l F	13		0.15	0.16	0.13	0.14	0.14	0.13	0.12
Bromide	mg/l Br	13		0.254	0.197	0.106	0.134	0.15	0.133	0.155
Chloride	mg/l Cl	52		92	96	84	73	81	79	84
Sulphate	mg/l SO_4	52		69	77	66	56	63	56	56
Sodium	mg/l Na	52		50.7	52.8	45.1	39.6	43.9	42.7	45.6
Potassium	mg/l K	52		7.2	7.3	5.9	4.9	5.8	5.2	5.1
Calcium	mg/l Ca	52		72	83	74	68	68	57	43
Magnesium	mg/l Mg	52		11.18	12.43	10.74	9.9	11.22	10.68	10.75
Total hardness	mmol/l	52		60.83	70.57	63.26	58.1	56.38	45.83	32.69
Total cyanide	µg/l CN	13	2	<	<	<	<	<	<	<
Eutrophying substances										
Ammonia	mg/l N	52	0.01	0.09	0.07	0.04	0.05	0.04	0.04	0.03
Kjeldahl nitrogen	mg/l N	26		1.05	0.97	0.81	0.86	0.74	1	1.32
Nitrate	mg/l N	52	0.02	3.06	3.78	3.73	3.03	2.19	1.13	0.23
Orthophosphate	mg/l P	52	0.01	0.055	0.059	0.038	0.011	<	<	<
Total phosphate	mg/l P	52	0.05	0.12	0.14	0.11	0.07	0.1	0.09	0.13
Heavy metals										
Iron	mg/l Fe	52		0.73	1.25	0.77	0.4	0.42	0.35	0.28
Manganese	mg/l Mn	13		0.03	0.12	0.11	0.03	0.07	0.08	0.07
Aluminium	µg/l Al	13		83	670	493	95	125	81	33
Aluminium (after filtration)	µg/l Al	13	5	7.27	<	10.86	<	<	<	<
Arsenicum	µg/l As	13	1	<	2	2	<	<	2	1.32
Barium	µg/l Ba	13		56	66	71	60	61	60	49
Beryllium	µg/l Be	13	0.05	<	<	<	<	<	<	<
Boron	mg/l B	13		0.09	0.11	0.08	0.06	0.07	0.06	0.07
Cadmium	µg/l Cd	13	0.1	<	<	<	<	<	<	<
Chromium	µg/l Cr	13	0.8	<	<	1.8	<	<	<	<
Copper	µg/l Cu	13	3	<	<	4	<	3.4	<	<
Mercury	µg/l Hg	12	0.02	<	0.028	0.045	<	<	0.04	0.093
Lead	µg/l Pb	13	0.5	<	2.2	3.4	<	1.6	0.6	1
Nickel	µg/l Ni	13	5	<	<	<	<	<	<	<
Selenium	µg/l Se	13	1	<	<	<	<	<	<	<
Zinc	µg/l Zn	13	1	2	16	18	4	5	<	1

n	number of observations during the year under review	min.	minimum
d.l.	detection limit	av.	average
10%, 50%, 90%	10%, 50%, 90% of the measurements are beneath the reported value	max.	maximum

Parameter	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**	min.	av.	max.	10%	50%	90%
General parameter											
TTemperature	19.1	18.5	10.2	7.6	4.4	2.2	8.1	21.9	3	5.4	18.1
Oxygen, dissolved	8.3	6.6	9.4	11.1	11.6	4.9	10	12.6	7.5	10.3	12
Oxygen saturation	77	61	83	91	89	45	85	103	69	89	92
Suspended matter	16.2	19.2	19.6	24.2	39.3	3.8	21.7	72.8	8.4	19.1	34
Residual ß-radioactivity (tot.-K40)	<		<	<		<	<	<			
Tritium	<		<	<		<	<	<			
pH-value	8.7	8.3	8.28	8.5	8.2	8	8.51	9.2	8.2	8.5	8.9
Inorganic substances											
ECC (electrical conductivity at 20°C)	50	54	65	65	73	48	63	85	52	64	71
Bicarbonate	91	100	131	128	157	78	136	200	91	141	167
Fluoride	0.12	0.13	0.13	0.14	0.13	0.12	0.13	0.16	0.12	0.13	0.14
Bromide	0.141	0.154	0.173	0.199	0.236	0.106	0.172	0.254	0.133	0.155	0.201
Chloride	91	98	113	120	128	63	95	134	77	91	120
Sulphate	54	54	66	67	72	50	63	93	53	62	74
Sodium	49.5	53.4	65	66.7	71.4	32.8	52.1	75.9	41	48.9	68.6
Potassium	5.3	5.4	5.9	5.9	6.3	4.1	5.8	8.1	4.8	5.8	7
Calcium	40	42	59	57	70	37	61	96	42	64	76
Magnesium	10.79	11.38	12.23	12.51	12.59	8.8	11.36	14.8	10	11.2	12.67
Total hardness	28.9	30.54	46.64	44.58	57.81	25.92	49.57	81.2	30.36	52	64.7
Total cyanide	<	<	<	<	<	<	<	<	<	<	<
Eutrophying substances											
Ammonia	0.1	0.17	0.14	0.02	0.07	<	0.07	0.32	0.02	0.05	0.14
Kjeldahl nitrogen	1.33	1.27	1.06	1.56	1.33	0.51	1.11	1.78	0.73	1.09	1.41
Nitrate	0.05	0.06	0.73	0.44	1.33	<	1.64	3.99	0.04	1.44	3.74
Orthophosphate	0.032	0.078	0.031	<	0.025	<	0.029	0.144	<	0.02	0.06
Total phosphate	0.13	0.2	0.16	0.13	0.17	<	0.13	0.26	0.07	0.13	0.18
Heavy metals											
Iron	0.23	0.35	0.55	0.43	0.86	0.08	0.55	1.85	0.18	0.41	1.12
Manganese	0.15	0.11	0.12	0.07	0.06	0.03	0.08	0.15	0.03	0.08	0.12
Aluminium	12	12	42	54	73	12	141	670	12	73	125
Aluminium (after filtration)	<	<	<	<	<	<	<	10.86	<	<	<
Arsenicum	2.88	3.18	2.48	1.81	1.49	<	1.73	3.18	<	2	2.48
Barium	58	51	58	64	70	49	61	71	51	60	66
Beryllium	<	<	<	<	<	<	<	<	<	<	<
Boron	0.06	0.09	0.07	0.09	0.1	0.06	0.08	0.11	0.06	0.08	0.09
Cadmium	<	<	<	<	<	<	<	<	<	<	<
Chromium	<	<	<	<	<	<	<	1.8	<	<	<
Copper	<	<	<	<	<	<	<	4	<	<	<
Mercury	<	<	<	0.097		<	0.038	0.185	<	<	0.045
Lead	0.8	<	1.1	1.4	2.6	<	1.3	3.4	<	1	2.2
Nickel	<	<	<	<	<	<	<	<	<	<	<
Selenium	<	<	<	<	<	<	<	<	<	<	<
Zinc	1	<	2	3	5	<	5	18	<	2	5

Parameter	unit	n	d.l.	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**June**	**July**
Organic substances, individual compounds										
Volatile chlorinated hydrocarbons										
1,2-dichloroethane	µg/l	18	2	<	<	<	<	<	<	<
trichloromethane	µg/l	18	0.1	<	<	<	0.27	<	<	<
1,1,1-trichloroethane	µg/l	18	0.1	<	<	<	<	<	<	<
1,1,2-trichloroethane	µg/l	18	0.1	<	<	<	<	<	<	<
trichloroethene	µg/l	18	0.1	<	<	<	<	<	<	<
1,2,3-trichloropropane	µg/l	17	0.2	<	<	<	<	<	<	<
tetrachloromethane	µg/l	18	0.1	<	<	<	<	<	<	<
tetrachloroethane	µg/l	18	0.1	<	<	<	<	<	<	<
tetrachloroethene	µg/l	18	0.1	<	<	<	<	<	<	<
bromochloromethane	µg/l	18	0.1	<	<	<	<	<	<	<
bromodichloromethane	µg/l	18	0.1	<	<	<	<	<	<	<
dibromochloromethane	µg/l	18	0.1	<	<	<	<	<	<	<
tribromomethane	µg/l	18	0.1	<	<	<	<	<	<	<
Chlorophenoles										
2-chlorophenol	µg/l	5	0.02		<		<			
3-chlorophenol	µg/l	5	0.02		<		<			
4-chlorophenol	µg/l	5	0.02		<		<			
2,3-dichlorophenol	µg/l	5	0.02		<		<			
2,4-dichlorophenol	µg/l	5	0.02		<		<			
2,6-dichlorophenol	µg/l	5	0.02		<		<			
3,4-dichlorophenol	µg/l	5	0.02		<		<			
3,5-dichlorophenol	µg/l	5	0.02		<		<			
2,3,4-trichlorophenol	µg/l	5	0.02		<		<			
2,3,5-trichlorophenol	µg/l	5	0.02		<		<			
2,3,6-trichlorophenol	µg/l	5	0.02		<		<			
2,4,5-trichlorophenol	µg/l	5	0.02		<		<			
2,4,6-trichlorophenol	µg/l	5	0.02		<		<			
3,4,5-trichlorophenol	µg/l	5	0.02		<		<			
2,3,4,5-tetrachlorophenol	µg/l	5	0.02		<		<			
2,3,4,6-tetrachlorophenol	µg/l	5	0.02		<		<			
2,3,5,6-tetrachlorophenol	µg/l	5	0.02		<		<			
pentachlorophenol	µg/l	5	0.02		<		<			
Volatile aromatic hydrocarbons (MAC)										
chlorobenzene	µg/l	6	0.05		<		<		<	
methylbenzene	µg/l	6	0.05		<		<		<	
benzene	µg/l	6	0.05		<		<		<	
1,2-dimethylbenzene	µg/l	6	0.05		<		<		<	
Meta + paraxylene	ug/l	6	0.05		<		<		<	
ethylbenzene	µg/l	6	0.05		<		<		<	
ethenylbenzene	µg/l	6	0.05		<		<		<	

Parameter	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**	min.	av.	max.	10%	50%	90%
Organic substances, individual compounds											
Volatile chlorinated hydrocarbons											
1,2-dichloroethane	<		<	<		<	<	<	<	<	<
trichloromethane	<		<	<		<	<	0.49	<	<	<
1,1,1-trichloroethane	<		<	<		<	<	<	<	<	<
1,1,2-trichloroethane	<		<	<		<	<	<	<	<	<
trichloroethene	<		<	<		<	<	<	<	<	<
1,2,3-trichloropropane	<		<	<		<	<	<	<	<	<
tetrachloromethane	<		<	<		<	<	<	<	<	<
tetrachloroethane	<		<	<		<	<	<	<	<	<
tetrachloroethene	<		<	<		<	<	<	<	<	<
bromochloromethane	<		<	<		<	<	<	<	<	<
bromodichloromethane	<		<	<		<	<	<	<	<	<
dibromochloromethane	<		<	<		<	<	<	<	<	<
tribromomethane	<		<	<		<	<	<	<	<	<
Chlorophenoles											
2-chlorophenol	<		<	<		<	<	<			
3-chlorophenol	<		<	<		<	<	<			
4-chlorophenol	<		<	<		<	<	<			
2,3-dichlorophenol	<		<	<		<	<	<			
2,4-dichlorophenol	<		<	<		<	<	<			
2,6-dichlorophenol	<		<	<		<	<	<			
3,4-dichlorophenol	<		<	<		<	<	<			
3,5-dichlorophenol	<		<	<		<	<	<			
2,3,4-trichlorophenol	<		<	<		<	<	<			
2,3,5-trichlorophenol	<		<	<		<	<	<			
2,3,6-trichlorophenol	<		<	<		<	<	<			
2,4,5-trichlorophenol	<		<	<		<	<	<			
2,4,6-trichlorophenol	<		<	<		<	<	<			
3,4,5-trichlorophenol	<		<	<		<	<	<			
2,3,4,5-tetrachlorophenol	<		<	<		<	<	<			
2,3,4,6-tetrachlorophenol	<		<	<		<	<	<			
2,3,5,6-tetrachlorophenol	<		<	<		<	<	<			
pentachlorophenol	<		<	<		<	<	<			
Volatile aromatic hydrocarbons (MAC)											
chlorobenzene	<		<	<		<	<	<			
methylbenzene	<		<	<		<	<	<			
benzene	<		<	<		<	<	<			
1,2-dimethylbenzene	<		<	<		<	<	<			
Meta + paraxylene	<		<	<		<	<	<			
ethylbenzene	<		<	<		<	<	<			
ethenylbenzene	<		<	<		<	<	<			

Parameter	unit	n	d.l.	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**June**	**July**
Polycyclic aromatic hydrocarbons (PAH)										
benzo(b)fluoranthene	µg/l	12	0.01	<	0.02	0.03		<	<	<
benzo(k)fluoranthene	µg/l	12	0.01	<	<	0.01		<	<	<
benzo(ghi)perylene	µg/l	12	0.01	<	<	<		<	<	<
benzo(a)pyrene	µg/l	12	0.01	<	0.01	0.02		<	<	<
fluoranthene	µg/l	12	0.01	<	0.019	<		<	<	<
indeno (1,2,3-cd)pyrene	µg/l	12	0.01	<	0.019	<		<	<	<
PAH, 6 of Borneff	µg/l	12		0.03	0.08	0.07		0.03	0.03	0.03
anthracene	µg/l	12	0.01	<	<	<		<	<	<
benzo(a)anthracene	µg/l	12	0.01	<	<	0.01		<	<	<
chrysene	µg/l	12	0.01	<	<	0.01		<	<	<
dibenzo(a,h)anthracene	µg/l	12	0.01	<	<	<		<	<	<
phenantrene	µg/l	12	0.01	<	0.012	0.02		<	<	<
naphtalene	µg/l	12	0.05		<	<	<	<	<	<
fluorene	µg/l	12	0.01	<	<	<		<	<	<
pyrene	µg/l	12	0.01	<	0.013	0.02		<	<	<
Complexing agents										
EDTA	µg/l	13	2	6.3	9.8	8.6	6.4	7.7	5.8	6.4
Organic substances, sum and group parameters										
Dissolved organic carbon (DOC)	mg/l C	52		7.9	7.9	6.4	5.6	6.4	5.6	5.9
COD (Chemical oxygen demand)	mg/l O_2	26		26	24	21	21	19	27	27
COD (filtered)	mg/l O_2	26		20	20	16	15	12	15	15
Colour intensity, Pt/Co-scale	mg/l Pt	13		18	22	18	20	18	14	17
Anionic detergents	mg/l Na-l	6			0.01		0.014		0.01	
Non-ionic + cationic detergents	mg/l	6	0.02		0.05		0.06		<	
AOX (adsorbable organic halogens)	µg/l Cl	12		41.1	39.6	25.5	33.7	28.2	23.5	30.8
Cholinesterase inhibition	µg/l para	6	0.1		0.14		<		<	
Algae biomass										
Silicate	mg/l Si	52	0.2	4.22	4.97	3.36	1.75	0.56	0.47	0.74
Chlorophyll-a	µg/l	51		24	32	26	37	55	68	127
Pheophytine	µg/l	51		12	17	13	15	19	21	30
Bacteria										
Thermotolerant bacteria, Coligroup	n/100 ml	51		6	181	2	1	19	27	45
Escherichia coli	n/100 ml	52		6	181	2	1	13	27	45
Faecal streptococci	n/100 ml	52		1	42	1	1	3	8	11

Parameter	Aug.	Sep.	Oct.	Nov.	Dec.	min.	av.	max.	10%	50%	90%
Polycyclic aromatic hydrocarbons (PAH)											
benzo(b)fluoranthene	<	<	<	<	<	<	<	0.03	<	<	<
benzo(k)fluoranthene	<	<	<	<	<	<	<	0.01	<	<	<
benzo(ghi)perylene	<	<	<	<	<	<	<	<	<	<	<
benzo(a)pyrene	<	<	<	<	<	<	<	0.02	<	<	<
fluoranthene	<	<	<	<	0.017	<	<	0.019	<	<	<
indeno (1,2,3-cd)pyrene	<	<	<	<	<	<	<	0.019	<	<	<
PAH, 6 of Borneff	0.03	0.03	0.03	0.03	0.04	0.03	0.04	0.08	0.03	0.03	0.04
anthracene	<	<	<	<	<	<	<	<	<	<	<
benzo(a)anthracene	<	<	<	<	<	<	<	0.01	<	<	<
chrysene	<	<	<	<	<	<	<	0.01	<	<	<
dibenzo(a,h)anthracene	<	<	<	<	<	<	<	<	<	<	<
phenantrene	<	<	<	<	0.017	<	<	0.02	<	<	0.012
naphtalene	<	<	<	<	<	<	<	<	<	<	<
fluorene	<	<	<	<	<	<	<	<	<	<	<
pyrene	<	<	<	<	<	<	<	0.02	<	<	<
Complexing agents											
EDTA	<	5	2.7	6.15	9	<	6.23	9.8	2.7	6.4	8.6
Organic substances, sum and group parameters											
Dissolved organic carbon (DOC)	6.1	6.8	5.8	6.1	5.9	4.2	6.4	8.7	5.2	6.3	7.2
COD (Chemical oxygen demand)	28	33	20	31	30	14	26	37	17	26	31
COD (filtered)	15	22	12	16	15	11	16	26	12	15	19
Colour intensity, Pt/Co-scale	12	12	11	9	13	9	15	22	9	14	18
Anionic detergents	0.017		0.102	0.012		0.01	0.027	0.102			
Non-ionic + cationic detergents	0.04		<	<		<	0.03	0.06			
AOX (adsorbable organic halogens)	21.1		34.9	28.6	29.3	21.1	30.4	41.1	23.5	30.1	34.9
Cholinesterase inhibition	<		<	<		<	<	0.14			
Algae biomass											
Silicate	1.41	1.74	1.51	0.27	1.31	<	1.82	5.6	0.4	1.49	4.5
Chlorophyll-a	68	72	88	107	114	9	68	203	19	59	116
Pheophytine	20	25	34	39	42	5	24	58	8	21	41
Bacteria											
Thermotolerant bacteria, Coligroup	72	28	38	107	7	0	46	640	1	9	52
Escherichia coli	71	28	29	105	6	0	43	640	0	9	52
Faecal streptococci	11	32	27	22	7	0	13	150	0	4	29

The quality of the IJsselmeer water at Andijk in 2000

Supplement 4B

(monthly averages and index numbers)

Parameter	unit	n	d.l.	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**June**	**July**
General parameter										
Temperature	°C	48		3.5	4.8	5.9	8.9	14.9	16.3	16.9
Oxygen, dissolved	mg/l O_2	11		11.6	12.1	11.7	11.7	8.6	10.6	7.9
Oxygen saturation	%	11		86	93	96	98	80	99	74
Suspended matter	mg/l	10		19.6	22.8	20.8	16.4	12	14.7	30.4
Residual ß-radioactivity (tot.-K40)	Bq/l	2	0.1	<				<		
Tritium	Bq/l	6	5	<		<		<		<
pH-value	pH	48		8.28	8.27	8.4	8.77	8.6	8.53	8.74
Inorganic substances										
ECC (electrical conductivity at 20°C)	mS/m	13		69	63		59	60	57	58
Bicarbonate	mg/l HCO_3	41		166	167	159	151	140	125	102
Fluoride	mg/l F	11		0.15	0.15	0.14	0.14	0.14	0.14	0.13
Bromide	mg/l Br	7		0.237	0.238	0.134	0.149	0.16	0.189	0.196
Chloride	mg/l Cl	47		116	101	83	80	86	96	106
Sulphate	mg/l SO_4	47		76	73	70	64	64	64	66
Sodium	mg/l Na	48		64.4	54.1	45.3	44.2	47.5	52.7	58.3
Potassium	mg/l K	7		6.7	6.6	5.6	5.9	5.9	5.6	6.2
Calcium	mg/l Ca	41		73	77	72	72	64	57	49
Magnesium	mg/l Mg	41		12.51	11.85	11.14	10.79	11.07	11.56	12.05
Total hardness	mmol/l	41		60.34	64.67	61.31	61.07	52.72	45.67	37.32
Total cyanide	µg/l CN	4	2	<				<		
Eutrophying substances										
Ammonia	mg/l N	11	0.01	0.06	0.06	0.04	<	0.03	0.03	0.14
Kjeldahl nitrogen	mg/l N	20		1.19	0.7	0.84	1.31	0.91	1.38	1.44
Nitrate	mg/l N	23	0.01	1.8	3.4	3.5	3	2.07	1.02	0.3
Orthophosphate	mg/l P	18	0.002	0.024	0.041	0.039	<	0.007	0.002	0.016
Total phosphate	mg/l P	23	0.04	0.1	0.12	0.14	0.08	0.09	0.15	0.18
Heavy metals										
Iron	mg/l Fe	7		0.39	0.54	0.68	0.3	0.1	0.17	0.27
Manganese	mg/l Mn	11		0.03	0.04	0.03	0.03	0.01	0.05	0.09
Aluminium	µg/l Al	7		104	315	157	75	53	50	34
Arsenicum	µg/l As	11	0.11	3.57	<	1.09	1.09	<	<	1.17
Barium	µg/l Ba	11		64	62	58	59	54	61	56
Boron	mg/l B	11		0.08	0.1	0.07	0.06	0.08	0.08	0.07
Zinc	µg/l Zn	11		8	6	7	5	5	2	3
Organic substances, individual compounds										
Volatile chlorinated hydrocarbons										
1,2-dichloroethane	µg/l	4	2	<		<		<		<
trichloromethane	µg/l	4	0.1	<		<		<		<
1,1,1-trichloroethane	µg/l	4	0.1	<		<		<		<
trichloroethene	µg/l	4	0.1	<		<		<		<
tetrachloromethane	µg/l	4	0.1	<		<		<		<
tetrachloroethene	µg/l	4	0.1	<		<		<		<
bromodichloromethane	µg/l	4	0.1	<		<		<		<
dibromochloromethane	µg/l	4	0.1	<		<		<		<
tribromomethane	µg/l	4	0.1	<		<		<		<

n	number of observations during the year under review	min.	minimum
d.l.	detection limit	av.	average
10%, 50%, 90%	10%, 50%, 90% of the measurements are beneath the reported value	max.	maximum

Parameter	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**	min.	av.	max.	10%	50%	90%
General parameter											
Temperature	19.5	16.4	12.2	7	6.4	2.9	11.2	19.8	3.9	11.1	18.6
Oxygen, dissolved	9.4		7.9	10.4		7.1	10	12.1	7.9	10.4	11.7
Oxygen saturation	87		71	83		66	85	99	74	86	96
Suspended matter	28		13	11.5		11.5	18.9	30.4	11.8	18	29.2
Residual ß-radioactivity (tot.-K40)						<	<	<			
Tritium		<	<			<	<	<			
pH-value	8.75	8.27	8.16	8.2	8.3	7.8	8.44	9.4	8.1	8.35	8.8
Inorganic substances											
ECC (electrical conductivity at 20°C)	59	57		69	68	57	64	73	57	62	69
Bicarbonate	83	105	128	154		75	135	189	96	141	162
Fluoride	0.13		0.13	0.14		0.12	0.14	0.15	0.13	0.14	0.14
Bromide						0.134	0.186	0.238			
Chloride	112	113	116	117	110	75	104	133	84	107	120
Sulphate	62	66	64	69	69	60	67	86	61	66	75
Sodium	61.8	64.1	66.3	65.6	60.6	42.2	57.9	73.8	44.9	59.6	67.8
Potassium						5.6	6.1	6.7			
Calcium	39	47	53	64		35	61	83	44	63	73
Magnesium	11.28	12.41	12.12	12.24		10.67	11.78	13.86	10.81	11.64	12.92
Total hardness	27.29	34.37	41.2	52.06		24.62	49.37	71.78	32.12	51.38	61.56
Total cyanide		<			<	<	<	<			
Eutrophying substances											
Ammonia	0.03		0.16	0.06		<	0.07	0.18	0.03	0.06	0.14
Kjeldahl nitrogen	1.63	1.24	2.08	1.07	1.8	0.65	1.36	3.35	0.77	1.25	1.83
Nitrate	0.03	0.08	0.51	1.22	1.45	<	1.51	3.7	0.08	1.45	3.31
Orthophosphate	0.01	0.048	<	<		<	0.019	0.048	<	0.01	0.041
Total phosphate	0.18	0.15	0.19	0.14	0.17	<	0.14	0.33	0.08	0.12	0.21
Heavy metals											
Iron						0.1	0.35	0.68			
Manganese	0.13		0.13	0.05		0.01	0.07	0.15	0.03	0.05	0.1
Aluminium						34	112	315			
Arsenicum	<		1.48	<		<	0.95	3.57	<	<	1.17
Barium	51		75	66		51	62	85	54	61	64
Boron	0.07		0.08	0.09		0.06	0.08	0.1	0.07	0.08	0.08
Zinc	2		10	13		1	6	19	2	5	8
Organic substances, individual compounds											
Volatile chlorinated hydrocarbons											
1,2-dichloroethane						<	<	<			
trichloromethane						<	<	<			
1,1,1-trichloroethane						<	<	<			
trichloroethene						<	<	<			
tetrachloromethane						<	<	<			
tetrachloroethene						<	<	<			
bromodichloromethane						<	<	<			
dibromochloromethane						<	<	<			
tribromomethane						<	<	<			

Parameter	unit	n	d.l.	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**June**	**July**
Volatile aromatic hydrocarbons (MAC)										
methylbenzene	µg/l	4	0.05	<		<		<		<
benzene	µg/l	4	0.05	<		<		<		<
1,2-dimethylbenzene	µg/l	4	0.05	<		<		<		<
ethylbenzene	µg/l	4	0.05	<		<		<		<
ethenylbenzene	µg/l	4	0.05	<		<		<		<
Polycyclic aromatic hydrocarbons (PAH)										
benzo(b)fluoranthene	µg/l	4	0.01	<				<		
benzo(k)fluoranthene	µg/l	4	0.01	<				<		
benzo(ghi)perylene	µg/l	4	0.01	<				<		
benzo(a)pyrene	µg/l	4	0.01	<				<		
fluoranthene	µg/l	4	0.01	<				<		
indeno (1,2,3-cd)pyrene	µg/l	4	0.01	<				<		
PAH, 6 of Borneff	µg/l	4		0.03				0.03		
anthracene	µg/l	4	0.01	<				<		
benzo(a)anthracene	µg/l	4	0.01	<				<		
chrysene	µg/l	4	0.01	<				<		
dibenzo(a,h)anthracene	µg/l	4	0.01	<				<		
phenantrene	µg/l	4	0.01	<				<		
naphtalene	µg/l	6	0.05	<		<		<		<
fluorene	µg/l	4	0.01	<				<		
pyrene	µg/l	4	0.01	<				<		
Organic substances, sum and group parameters										
Colour intensity, Pt/Co-scale	mg/l Pt	11		14	19	22	22	17	15	15
Anionic active detergents	mg/l Na-l	5		0.014		0.017		0.016		0.016
Non-ionic + cationic detergents	mg/l	4	0.02	<		0.09		<		<
AOX (adsorbable organic halogens)	µg/l Cl	7		21.8	27.9	30	30.6	29.1	30.7	27.5
Algae biomass										
Chlorophyll-a	µg/l	13		70	54	36	72	16	78	87
Pheophytine	µg/l	11		26	16	13	20	4	23	29
Bacteriën										
Thermotolerant bacteria, Coligroup	n/100 ml	47		38	23	8	2	7	11	33
Escherichia coli	n/100 ml	40		33	23	8	1	6	11	25
Faecal streptococci	n/100 ml	47		6	20	1	1	16	17	2

Parameter	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**	min.	av.	max.	10%	50%	90%
olatile aromatic hydrocarbons (MAC)											
methylbenzene						<	<	<			
benzene						<	<	<			
1,2-dimethylbenzene						<	<	<			
ethylbenzene						<	<	<			
ethenylbenzene						<	<	<			
Polycyclic aromatic hydrocarbons (PAH)											
benzo(b)fluoranthene		0.01			<	<	<	0.01			
benzo(k)fluoranthene		<			<	<	<	<			
benzo(ghi)perylene		<			<	<	<	<			
benzo(a)pyrene		<			<	<	<	<			
fluoranthene		0.01			<	<	<	0.01			
indeno (1,2,3-cd)pyrene		<			<	<	<	<			
PAH, 6 of Borneff		0.04			0.03	0.03	0.03	0.04			
anthracene		<			<	<	<	<			
benzo(a)anthracene		<			<	<	<	<			
chrysene		<			<	<	<	<			
dibenzo(a,h)anthracene		<			<	<	<	<			
phenantrene		0.01			0.01	<	<	0.01			
naphtalene		<			<	<	<	<			
fluorene		<			<	<	<	<			
pyrene		0.01			<	<	<	0.01			
Organic substances, sum and group parameters											
Colour intensity, Pt/Co-scale	13		13	13		12	16	22	13	15	19
Anionic active detergents			0.019			0.014	0.016	0.019			
Non-ionic + cationic detergents						<	0.03	0.09			
AOX (adsorbable organic halogens)						21.8	28.2	30.7			
Algae biomass											
Chlorophyll-a	88	32	92	67	50	16	64	92	32	70	88
Pheophytine	21	16	29			4	20	33	13	21	26
Bacteriën											
Thermotolerant bacteria, Coligroup	53	71	12	8	2	0	23	144	1	9	74
Escherichia coli	66	53	10	7		0	22	126	0	8	85
Faecal streptococci	18	93	82	21	7	0	24	350	0	5	38

The quality of the Haringvliet water at Stellendam in 1999

Supplement 5A

(monthly averages and index numbers)

Parameter	unit	n	d.l.	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**June**	**July**
General parameter										
Temperature	°C	11			5.8	10.8	11.7	15.6	17.5	22
Oxygen, dissolved	mg/l O_2	12			12.4	10.9	10.2	10.1	9.6	10.2
Oxygen saturation	%	11			99	96	91	94	90	93
Suspended matter	mg/l	46		11.3	14.9	29.7	18	25.8	14	10.1
Residual ß-radioactivity (tot.-K40)	Bq/l	4	0.1			<			<	
pH-value	pH	12			8	7.8	8.1	8.4	8.3	8.63
Inorganic substances										
ECC (electrical conductivity at 20°C)	mS/m	12			55	52	53	55	52	56
Bicarbonate	mg/l HCO_3	12			160	172	175	176	173	160
Fluoride	mg/l F	12			0.19	0.21	0.15	0.15	0.16	0.16
Chloride	mg/l Cl	46		66	70	48	61	60	60	74
Sulphate	mg/l SO_4	12			51	48	49	56	46	49
Sodium	mg/l Na	45		32.3	38.2	24.5	32	31.6	31.8	41.7
Potassium	mg/l K	12			4.8	3.8	4.3	4.2	3.9	4.5
Calcium	mg/l Ca	12			66	69	68	70	64	66
Magnesium	mg/l Mg	12			10.25	9.5	10	11	10	10
Total hardness	mmol/l	12			55.75	59.5	58	59	54	56
Total cyanide	µg/l CN	4	0.5			0.6			<	
Eutrophying substances										
Ammonia	mg/l N	46	0.03	0.18	0.17	0.13	0.1	0.04	0.04	0.06
Kjeldahl nitrogen	mg/l N	8				0.6			0.6	0.6
Nitrate	mg/l N	23		4.3	4.33	3.8	3.4	3.15	2.17	1.7
Orthophosphate	mg/l P	23		0.1	0.097	0.095	0.07	0.035	0.063	0.04
Total phosphate	mg/l P	23		0.14	0.15	0.14	0.11	0.13	0.12	0.38
Heavy metals										
Iron	mg/l Fe	13	0.25		1.1	0.4	<	0.77	<	<
Manganese	mg/l Mn	12	0.03		0.06	0.1	0.03	0.04	<	0.03
Arsenicum	µg/l As	4	2			<			<	
Barium	µg/l Ba	4				56			62	
Boron	mg/l B	4				0.05			0.05	
Cadmium	µg/l Cd	4	0.2			<			<	
Chromium	µg/l Cr	4	1			1			1	
Copper	µg/l Cu	4	5			<			<	
Mercury	µg/l Hg	3	0.05						<	
Lead	µg/l Pb	4	2			<			<	
Nickel	µg/l Ni	4	3			<			<	
Selenium	µg/l Se	4	4			<			<	
Zinc	µg/l Zn	4	13			16			<	

n	number of observations during the year under review	min.	minimum
d.l.	detection limit	av.	average
10%, 50%, 90%	10%, 50%, 90% of the measurements are beneath the reported value	max.	maximum

Parameter	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**	min.	av.	max.	10%	50%	90%
General parameter											
Temperature	21.4		14.6	9.5		4.5	13.1	22	7.1	11.7	17.5
Oxygen, dissolved	7.7	7.7	9.6	11.4		7.7	10.3	12.5	7.7	10.2	12.2
Oxygen saturation	71		88	98		71	92	101	88	94	96
Suspended matter	12.7	10.6	22	6.7	9.9	4.5	15.4	60	7.1	11	27
Residual ß-radioactivity (tot.-K40)		<		<		<	<	<			
pH-value	8.3	8.1	8.4	8.25		7.8	8.21	8.63	8	8.25	8.4
Inorganic substances											
ECC (electrical conductivity at 20°C)	56	63	68	78		51	60	78	52	56	68
Bicarbonate	167	171	160	175		156	169	178	160	171	175
Fluoride	0.16	0.17	0.18	0.22		0.15	0.18	0.22	0.15	0.17	0.22
Chloride	86	104	126	134	118	42	85	156	55	77	133
Sulphate	50	56	59	73		46	55	73	48	52	59
Sodium	46.6	57.5	72.5	77.3	65	21	46.2	89	29	38.8	73
Potassium	4.5	5.4	5.3	6.3		3.8	4.8	6.5	3.9	4.7	5.4
Calcium	65	68	67	74		64	68	75	65	68	70
Magnesium	11	11	12	13		9.5	10.92	13	9.6	10.95	12
Total hardness	54	57	55	61		54	57.17	62	54	56.7	59.5
Total cyanide		1.4		<		<	0.6	1.4			
Eutrophying substances											
Ammonia	0.14	0.03	0.08	0.1	0.15	<	0.1	0.21	<	0.11	0.18
Kjeldahl nitrogen	0.6	0.4	0.4	0.45		0.4	0.51	0.6			
Nitrate	1.6	1.85	2.45	2.93	3.3	1.6	2.9	4.5	1.7	2.9	4.1
Orthophosphate	0.11	0.11	0.12	0.123	0.11	0.03	0.092	0.13	0.04	0.1	0.12
Total phosphate	0.16	0.15	0.17	0.15	0.27	0.09	0.16	0.38	0.12	0.14	0.19
Heavy metals											
Iron	0.28	0.3	0.95	0.37		<	0.47	1.4	<	0.37	0.8
Manganese	0.06	0.04	0.05	<		<	0.04	0.1	<	0.04	0.06
Arsenicum		3		2		<	<	3			
Barium		66		60		56	61	66			
Boron		0.07		0.08		0.05	0.06	0.08			
Cadmium		<		<		<	<	<			
Chromium		3		<		<	1.37	3			
Copper		<		<		<	<	<			
Mercury		<		<		<	<	<			
Lead		<		<		<	<	<			
Nickel		<		<		<	<	<			
Selenium		<		<		<	<	<			
Zinc		25		16		<	16	25			

Parameter	unit	n	d.l.	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**June**	**July**
Organic substances, individual compounds										
Volatile chlorinated hydrocarbons										
1,2-dichloropropane	µg/l	1	0.01			<				
Volatile aromatic hydrocarbons (MAC)										
methylbenzene	µg/l	4	0.1			<			<	
benzene	µg/l	4	0.1			<			<	
1,2-dimethylbenzene	µg/l	4	0.1			<			<	
Meta + paraxylene	ug/l	4	0.1			<			<	
ethylbenzene	µg/l	4	0.1			<			<	
ethenylbenzene	µg/l	4	0.1			<			<	
Polycyclic aromatic hydrocarbons (PAH)										
benzo(b)fluoranthene	µg/l	20	0.005		<	<	0.01	0.01	<	<
benzo(k)fluoranthene	µg/l	20	0.005		<	<	<	<	<	<
benzo(ghi)perylene	µg/l	20	0.005		<	<	0.01	0.01	<	<
benzo(a)pyrene	µg/l	20	0.005		<	<	0.01	<	<	<
fluoranthene	µg/l	20	0.005		0.018	0.017	0.01	0.01	0.017	<
indeno (1,2,3-cd)pyrene	µg/l	20	0.005		<	<	0.01	<	<	<
PAH, 6 of Borneff	µg/l	20			0.05	0.04	0.05	0.05	0.04	0.03
anthracene	µg/l	20	0.005		<	<	<	<	<	<
benzo(a)anthracene	µg/l	20	0.005		<	<	<	<	<	<
chrysene	µg/l	20	0.005		<	<	0.01	<	<	<
dibenzo(a,h)anthracene	µg/l	20	0.005		<	<	<	<	<	<
phenantrene	µg/l	20	0.005		<	0.012	0.01	<	<	<
naphtalene	µg/l	20	0.1	<	<	<	<	<	<	<
fluorene	µg/l	20	0.005		<	<	<	<	<	<
pyrene	µg/l	20	0.005		0.017	0.017	0.02	0.01	0.013	<
Organic substances, sum and group parameters										
COD (Chemical oxygen demand)	mg/l O_2	4	10			<			<	
COD (filtered)	mg/l O_2	12	10		<	<	12	10	<	
Colour intensity, Pt/Co-scale	mg/l Pt	12			13	11	11	11	10	9
Anionic active detergents	mg/l Na-l	4	0.02			<				
Phenoles, water vapour volatility	µg/l C6H5	4	1			1				
AOX (adsorbable organic halogens)	µg/l Cl	17			15	10	11	16	15	13.5
Cholinesterase inhibition	µg/l para	4	0.1			0.18			0.1	
Algae biomass										
Silicate	mg/l Si	4				2.5			0.8	
Chlorophyll-a	µg/l	46	2	<	<	4	14	27	14	17
Pheophytine	µg/l	23	2	<	2	5	7	12	9	7
Bacteria										
Thermotolerant bacteria, Coligroup	n/100 ml	23	1	24	29	141	18	2	25	4
Escherichia coli	n/100 ml	23	1	24	29	139	21	2	25	4
Faecal streptococci	n/100 ml	23	1	13	7	35	1	1	1	<

Parameter	Aug.	Sep.	Oct.	Nov.	Dec.	min.	av.	max.	10%	50%	90%
Organic substances, individual compounds											
Volatile chlorinated hydrocarbons											
1,2-dichloropropane						<	<	<			
Volatile aromatic hydrocarbons (MAC)											
methylbenzene		<		<		<	<	<			
benzene		<		<		<	<	<			
1,2-dimethylbenzene		<		<		<	<	<			
Meta + paraxylene		<		<		<	<	<			
ethylbenzene		<		<		<	<	<			
ethenylbenzene		<		<		<	<	<			
Polycyclic aromatic hydrocarbons (PAH)											
benzo(b)fluoranthene	<	<	<	<	<	<	0.007	0.02	<	<	0.01
benzo(k)fluoranthene	<	<	<	<	<	<	<	<	<	<	<
benzo(ghi)perylene	<	<	<	<	<	<	0.006	0.01	<	<	0.01
benzo(a)pyrene	<	<	<	<	<	<	0.005	0.01	<	<	0.01
fluoranthene	0.015	<	0.01	<	0.01	<	0.012	0.03	<	0.01	0.025
indeno (1,2,3-cd)pyrene	<	<	<	<	<	<	0.006	0.01	<	<	0.01
PAH, 6 of Borneff	0.04	0.03	0.03	0.02	0.03	0.01	0.04	0.08	0.03	0.03	0.06
anthracene	<	<	<	<	<	<	<	<	<	<	<
benzo(a)anthracene	<	<	<	<	<	<	<	<	<	<	<
chrysene	<	<	<	<	<	<	0.006	0.01	<	<	0.01
dibenzo(a,h)anthracene	<	<	<	<	<	<	<	<	<	<	<
phenantrene	0.017	<	<	<	<	<	0.008	0.03	<	<	0.015
naphtalene	<	<	<	<	<	<	<	<	<	<	<
fluorene	<	<	<	<	<	<	0.005	0.01	<	<	0.01
pyrene	<	<	<	<	0.01	<	0.011	0.03	<	0.01	0.02
Organic substances, sum and group parameters											
COD (Chemical oxygen demand)		<		<		<	<	<			
COD (filtered)	<	<	<	<	11	<	<	12	<	<	11
Colour intensity, Pt/Co-scale	8	8	11	9		8	10	14	8	11	11
Anionic active detergents	<	<		0.02		<	<	0.02			
Phenoles, water vapour volatility	<	<		<		<	<	1			
AOX (adsorbable organic halogens)	9		16	15	18	8	13.9	23	10	15	18
Cholinesterase inhibition		<		<		<	<	0.18			
Algae biomass											
Silicate		1.2		2.8		0.8	1.83	2.8			
Chlorophyll-a	11	12	5	3	<	<	9	42	<	4	19
Pheophytine	6	4	4	2	2	<	5	12	2	4	10
Bacteria											
Thermotolerant bacteria, Coligroup	332	21	4	17	28	<	56	640	2	21	41
Escherichia coli	441	8	4	15	28	<	64	860	2	21	40
Faecal streptococci	316	5	5	4	6	<	34	620	<	6	12

The quality of the Haringvliet water at Stellendam in 2000

Supplement 5B

(monthly averages and index numbers)

Parameter	unit	n	d.l.	Jan.	Feb.	Mar.	Apr.	May	June	July
General parameter										
Temperature	°C	13		5	6	8.5	10.8	19.6	18.3	17.2
Oxygen, dissolved	mg/l O_2	13		12.5	11.8	11.6	11.3	10.5	9.1	9.2
Oxygen saturation	%	13		98	94	98	99	98	85	86
Suspended matter	mg/l	52		22.3	15.6	12.3	7.6	14.7	27.8	12.4
pH-value	pH	13		8.2	8.1	8.2	8.3	8.5	8.3	8.3
Inorganic substances										
ECC (electrical conductivity at 20°C)	mS/m	13		55	48	44	57	61	61	65
Bicarbonate	mg/l HCO_3	13		168	148	144	170	185	165	165
Fluoride	mg/l F	13		0.16	0.17	0.15	0.17	0.18	0.18	0.19
Chloride	mg/l Cl	52		53	66	53	69	83	85	93
Sulphate	mg/l SO_4	13		50	47	44	51	61	58	60
Sodium	mg/l Na	52		24	33.8	28	35.8	46.6	45.3	52.3
Potassium	mg/l K	13		4.3	4.2	3.9	4.5	5.3	4.7	5.9
Calcium	mg/l Ca	13		71	63	59	68	73	71	64
Magnesium	mg/l Mg	13		9	9	8	11	11	10	11
Total hardness	mmol/l	13		62	54	51	57	62	61	53
Total cyanide	µg/l CN	4				0.5				
Eutrophying substances										
Ammonia	mg/l N	52	0.03	0.17	0.16	0.1	0.07	0.08	0.09	0.1
Kjeldahl nitrogen	mg/l N	4				0.3				0.6
Nitrate	mg/l N	26		3.9	3.85	3.8	3.8	2.6	2.25	2.35
Orthophosphate	mg/l P	26	0.02	0.09	0.1	0.08	0.075	0.043	0.095	0.135
Total phosphate	mg/l P	26		0.11	0.14	0.11	0.11	0.11	0.15	0.2
Heavy metals										
Iron	mg/l Fe	12		0.27		0.37	0.41	0.53	1.08	0.49
Manganese	mg/l Mn	12		0.06		0.06	0.05	0.04	0.07	0.08
Arsenicum	µg/l As	4				<				
Barium	µg/l Ba	4				53				55
Boron	mg/l B	4				<				0.06
Cadmium	µg/l Cd	4	0.2			<				<
Chromium	µg/l Cr	4	1			1				1
Copper	µg/l Cu	4	5			<				<
Mercury	µg/l Hg	4	0.05			<				<
Lead	µg/l Pb	4	2			<				<
Nickel	µg/l Ni	4	3			<				5
Selenium	µg/l Se	4	1			<				<
Zinc	µg/l Zn	5				16				6

n	number of observations during the year under review	min.	minimum
d.l.	detection limit	av.	average
10%, 50%, 90%	10%, 50%, 90% of the measurements are beneath the reported value	max.	maximum

Parameter	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**	min.	av.	max.	10%	50%	90%
General parameter											
Temperature	20.6	18.5	14.3	8.5	3.3	3.3	12.7	20.6	5	11.4	18.5
Oxygen, dissolved	9.4	8.9	9.8	12.4	12.3	8.8	10.7	12.5	8.9	10.8	12.3
Oxygen saturation	87	83	89	104	92	82	92	104	83	94	98
Suspended matter	10.6	7	10.9	9.5	11.8	4.1	13.5	57	6.8	12	18
pH-value	8.2	8.2	8.35	8.2	8.2	8.1	8.26	8.5	8.2	8.2	8.3
Inorganic substances											
ECC (electrical conductivity at 20°C)	51	57	63	55	53	44	56	65	48	57	61
Bicarbonate	145	150	163	160	160	144	160	185	145	160	168
Fluoride	0.29	0.17	0.22	0.2	0.21	0.15	0.19	0.29	0.16	0.18	0.21
Chloride	71	84	97	83	63	41	75	106	52	76	93
Sulphate	46	48	60	49	43	43	52	65	44	50	60
Sodium	39.2	60.5	54	46	33	19	41.7	89	26	40.5	55
Potassium	4.8	4.5	5.8	5.1	4.9	3.9	4.9	6.4	4.2	4.8	5.3
Calcium	60	61	67	67	67	59	66	73	60	67	71
Magnesium	9	11	11	10	9	8	10	11	9	10	11
Total hardness	51	50	55.5	57	58	50	55.92	62	51	56	61
Total cyanide		0.5		1	1	0.5	0.8	1			
Eutrophying substances											
Ammonia	0.05	0.07	0.09	0.11	0.12	<	0.1	0.19	0.04	0.1	0.17
Kjeldahl nitrogen		0.5			0.5	0.3	0.47	0.6			
Nitrate	2.4	2.1	2.77	3.4	3.4	1.9	3.02	4	2.1	3.15	3.9
Orthophosphate	0.135	0.125	0.11	0.12	0.105	<	0.099	0.18	0.07	0.1	0.13
Total phosphate	0.16	0.14	0.15	0.15	0.13	0.07	0.14	0.26	0.11	0.14	0.15
Heavy metals											
Iron	0.5	0.63	0.61	0.9	0.74	0.27	0.59	1.08	0.37	0.51	0.74
Manganese	0.04	0.06	<	0.04	0.03	0.03	0.05	0.08	0.03	0.05	0.06
Arsenicum		2			<		1	2			
Barium		58			43	43	52	58			
Boron		0.07			0.04	0.04	0.05	0.07			
Cadmium		<			<	<	<	<			
Chromium		<			<	<	<	1			
Copper		<			<	<	<	<			
Mercury		<			<	<	<	<			
Lead		<			<	<	<	<			
Nickel		4			4	<	3.6	5			
Selenium		<			<	<	<	<			
Zinc		15			17	0	12	17			

Parameter	unit	n	d.l.	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**June**	**July**
Organic substances, individual compounds										
Polycyclic aromatic hydrocarbons (PAH)										
benzo(b)fluoranthene	µg/l	26	0.01	<	<	<	<	<	<	<
benzo(k)fluoranthene	µg/l	26	0.01	<	<	<	<	<	<	<
benzo(ghi)perylene	µg/l	26	0.01	<	<	<	<	<	<	<
benzo(a)pyrene	µg/l	26	0.01	<	<	<	<	<	<	<
fluoranthene	µg/l	26	0.01	<	<	0.012	<	<	0.012	<
indeno (1,2,3-cd)pyrene	µg/l	26	0.01	<	<	<	<	<	0.012	<
PAH, 6 of Borneff	µg/l	26		0.03	0.03	0.04	0.03	0.03	0.05	0.03
anthracene	µg/l	26	0.01	<	<	<	<	<	<	<
benzo(a)anthracene	µg/l	26	0.01	<	<	<	<	<	<	<
chrysene	µg/l	26	0.01	<	<	<	<	<	<	<
dibenzo(a,h)anthracene	µg/l	26	0.01	<	<	<	<	<	<	<
phenantrene	µg/l	26	0.01	<	<	0.012	<	<	<	<
naphtalene	µg/l	26	0.01	<	<	<	<	0.03	<	<
fluorene	µg/l	26	0.01	<	<	<	<	<	<	<
pyrene	µg/l	26	0.01	<	<	<	<	<	<	<
Organic substances, sum and group parameters										
COD (filtered)	mg/l O_2	13		<	<	<	11	<	<	<
Colour intensity, Pt/Co-scale	mg/l Pt	13		11	13	12	11	12	10	9
Anionic active detergents	mg/l Na-l	4	0.02			0.02				0.02
AOX (adsorbable organic halogens)	µg/l Cl	26		13	12.5	14.5	<	10	14.5	45
Cholinesterase inhibition	µg/l para	3	0.1			<				
Algae biomass										
Chlorophyll-a	µg/l	52		<	<	4	8	30	15	11
Pheophytine	µg/l	26	2	<	3	4	3	11	7	9
Bacteria										
Thermotolerant bacteria, Coligroup	n/100 ml	26	1	54	40	36	4	23	6	3
Escherichia coli	n/100 ml	26	1	54	47	36	4	23	6	3
Faecal streptococci	n/100 ml	26	1	34	24	11	1	2	1	<

Parameter	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**	min.	av.	max.	10%	50%	90%
Organic substances, individual compounds											
Polycyclic aromatic hydrocarbons (PAH)											
benzo(b)fluoranthene	<	<	<	<	<	<	<	<	<	<	0.01
benzo(k)fluoranthene	<	<	<	<	<	<	<	<	<	<	<
benzo(ghi)perylene	<	<	<	<	<	<	<	<	<	<	<
benzo(a)pyrene	<	<	<	<	<	<	<	<	<	<	0.01
fluoranthene	<	<	<	<	<	<	<	0.02	<	<	<
indeno (1,2,3-cd)pyrene	<	<	<	<	<	<	<	0.02	<	<	<
PAH, 6 of Borneff	0.03	0.03	0.06	0.03	0.03	0.03	0.04	0.07	0.03	0.03	0.06
anthracene	<	<	<	<	0.027	<	<	<	<	<	<
benzo(a)anthracene	<	<	<	<	0.027	<	<	<	<	<	<
chrysene	<	<	<	<	<	<	<	<	<	<	<
dibenzo(a,h)anthracene	<	<	<	<	<	<	<	<	<	<	<
phenantrene	<	<	<	<	<	<	<	0.02	<	<	<
naphtalene	<	<	<	<	<	<	0.05	<	<	<	<
fluorene	<	<	<	<	<	<	<	<	<	<	0.01
pyrene	<	<	<	<	<	<	<	<	<	<	0.01
Organic substances, sum and group parameters											
COD (filtered)	7	13	11	12	9	7	8	13	9	<	11
Colour intensity, Pt/Co-scale	12	10	11	14	16	9	12	16	9	12	13
Anionic active detergents		<			<	<	<	0.02			
AOX (adsorbable organic halogens)	40	27.5	20.3	13	14.5	8	19.2	56	<	14	43
Cholinesterase inhibition		<		0.22		<	0.11	0.22			
Algae biomass											
Chlorophyll-a	8	6	3	<	<	1	8	89	<	3	15
Pheophytine	8	3	4	2	2	<	5	16	2	3	11
Bacteria											
Thermotolerant bacteria, Coligroup	2	4	14	49	41	<	23	90	<	10	56
Escherichia coli	2	8	15	51	54	<	25	90	<	15	62
Faecal streptococci	<	4	5	19	27	<	10	61	<	3	29

Pesticides and other substances in the Rhine water at Lobith during 1999

(monthly averages and index numbers)

Supplement 6A

Parameter	unit	n	d.l.	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**June**	**July**
aldicarb	µg/l	13	0.05	<	<	<	<	<	<	<
aldicarb-sulfone	µg/l	13	0.2	<	<	<	<	<	<	<
aldicarb-sulphoxide	µg/l	13	0.05	<	<	<	<	<	<	<
aminomethylphosphonic acid (AMPA)	µg/l	13		0.18	0.13	0.09	0.16	0.19	0.18	0.31
atrazine	µg/l	13	0.01	0.03	0.04	0.02	0.03	0.09	0.08	0.09
azinphos-methyl	µg/l	7	0.01	<	<	<				
bentazon	µg/l	13	0.03	<	<	<	<	<	<	<
carbaryl	µg/l	13	0.01	<	<	<	<	<	<	<
carbofuran	µg/l	13	0.05	<	<	<	<	<	<	<
chlorofenvinfos	µg/l	13	0.01	<	<	<	<	<	<	<
chlorotoluron	µg/l	13	0.05	<	<	<	<	<	<	<
2,4-D (2,4-dichlorofenoxy-acetic acid)	µg/l	13	0.02	<	<	<	<	<	<	0.05
dalapon (2,2-dichloropropionic acid)	µg/l	6	1		<		<		<	
diazinone	µg/l	13	0.01	<	<	<	<	<	<	<
dichloroprop (2,4-DP)	µg/l	13	0.02	<	<	<	0.04	0.04	<	0.05
1,2-dichloropropane	µg/l	13	0.01	<	<	0.01	0.01	<	<	0.01
1,3-dichloropropane	µg/l	13	0.01	<	<	<	<	<	<	<
cis 1,3 dichloropropene	µg/l	13	0.01	<	<	<	<	<	<	<
trans 1,3 dichloropropene	µg/l	13	0.01	<	<	<	<	<	<	<
dichlorovos	µg/l	13	0.01	<	<	<	<	<	<	<
dimethoate	µg/l	12	0.05	<	<	<		<	<	<
2,4-dinitrophenol	µg/l	13	0.2	<	<	<	<	<	<	<
dinoseb (2-sec.butyl-4,6-dinitrophenol)	µg/l	13	0.03	<	<	<	<	<	<	<
dinoterb (2-tert.butyl-4,6-dinitrophenol)	µg/l	13	0.03	<	<	<	<	<	<	<
diuron	µg/l	13	0.05	<	<	<	<	<	<	0.06
DNOC (2-methyl-4,6-dinitrophenol)	µg/l	13	0.03	<	<	<	<	<	<	<
α-endosulfan	µg/l	6	0.01		<		<		<	
glyphosphate	µg/l	13	0.05	<	<	<	0.05	0.06	<	0.06
hexachloro benzene (HCB)	µg/l	6	0.01		<		<		<	
α-HCH (α-hexachloro cyclohexane)	µg/l	6	0.01		<		<		<	
isoproturon	µg/l	13	0.05	0.07	<	<	0.17	0.09	<	<
lindane	µg/l	6	0.01		<		<		<	
linuron	µg/l	13	0.05	<	<	<	<	<	<	<
malathion	µg/l	13	0.01	<	<	<	<	<	<	<
MCPA (4-chloro-2-methylphenoxy-acetic acid)	µg/l	13	0.02	<	<	<	0.04	0.02	<	0.06
mecoprop (MCPP)	µg/l	13	0.02	<	0.06	<	0.05	0.03	<	0.03
methabenzthiazuron	µg/l	13	0.01	<	<	<	<	<	<	<
methomyl	µg/l	13	0.05	<	<	<	<	<	<	<
metobromuron	µg/l	13	0.05	<	<	<	<	<	<	<
metoxuron	µg/l	13	0.05	<	<	<	<	<	<	<
naphtalene	µg/l	6			<		<		0.05	
oxamyl	µg/l	13	0.05	<	<	<	<	<	<	<
parathion-ethyl	µg/l	11	0.01	<	<	<		<		<
parathion-methyl	µg/l	9	0.05	<	<	<		<		
pentachlorophenol	µg/l	11	0.01	0.03	<	<	<	<	<	
propazine	µg/l	13	0.01	<	<	<	<	<	<	<
propoxur	µg/l	13	0.05	<	<	<	<	<	<	<
pyrazophos	µg/l	11	0.1	<	<	<	<	<		
simazin	µg/l	13	0.01	<	0.02	0.02	0.02	0.01	0.02	0.02
TCA (trichloroacetic acid)	µg/l	6	0.1		<		<		0.2	
terbutylazine	µg/l	12	0.01		0.03	0.02	<	0.01	0.01	0.02
2,4,5-trichlorophenol	µg/l	11	0.01	<	<	<	<	<	<	
2,4,6-trichlorophenol	µg/l	11	0.01	0.01	<	<	<	<	<	

n	number of observations during the year under review	min.	minimum
d.l.	detection limit	av.	average
10%, 50%, 90%	10%, 50%, 90% of the measurements are beneath the reported value	max.	maximum

Parameter	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**	min.	av.	max.	10%	50%	90%
aldicarb	<	<	<	<	<	<	<	<	<	<	<
aldicarb-sulfone	<	<	<	<	<	<	<	<	<	<	<
aldicarb-sulphoxide	<	<	<	<	<	<	<	<	<	<	<
aminomethylphosphonic acid (AMPA)	0.43	0.39	0.43	0.34	0.19	0.09	0.25	0.43	0.12	0.19	0.39
atrazine	0.05	0.06	<	0.03	0.01	<	0.04	0.09	<	0.03	0.08
azinphos-methyl			<	<	<	<	<	<			
bentazon	<	<	<	<	<	<	<	<	<	<	<
carbaryl	<	<	<	<	<	<	<	<	<	<	<
carbofuran	<	<	<	<	<	<	<	<	<	<	<
chlorofenvinfos	<	<	<	<	<	<	<	<	<	<	<
chlorotoluron	<	<	<	<	<	<	<	0.06	<	<	<
2,4-D (2,4-dichlorofenoxy-acetic acid)	<	<	<	<	<	<	<	0.05	<	<	<
dalapon (2,2-dichloropropionic acid)	<		<		<	<	<	<			
diazinone	<	<	<	<	<	<	<	<	<	<	<
dichloroprop (2,4-DP)	<	<	<	<	<	<	<	0.05	<	<	0.04
1,2-dichloropropane	<	0.01	<	<	<	<	<	0.01	<	<	0.01
1,3-dichloropropane	<	<	<	<	<	<	<	<	<	<	<
cis 1,3 dichloropropene	<	<	<	<	<	<	<	<	<	<	<
trans 1,3 dichloropropene	<	<	<	<	<	<	<	<	<	<	<
dichlorovos	<	<	<	<	<	<	<	<	<	<	<
dimethoate	<	<	<	<	<	<	<	<	<	<	<
2,4-dinitrophenol	<	<	<	<	<	<	<	<	<	<	<
dinoseb (2-sec.butyl-4,6-dinitrophenol)	<	<	<	<	<	<	<	<	<	<	<
dinoterb (2-tert.butyl-4,6-dinitrophenol)	<	<	<	<	<	<	<	<	<	<	<
diuron	<	<	<	<	<	<	<	0.06	<	<	<
DNOC (2-methyl-4,6-dinitrophenol)	<	<	<	<	<	<	<	<	<	<	<
α-endosulfan	<		<		<	<	<	<			
glyphosphate	0.07	<	<	0.08	<	<	<	0.08	<	<	0.06
hexachloro benzene (HCB)	<		<		<	<	<	<			
α-HCH (α-hexachloro cyclohexane)	<		<		<	<	<	<			
isoproturon	<	<	<	0.1	0.075	<	0.058	0.17	<	<	0.09
lindane	<		<		<	<	<	<			
linuron	<	<	<	<	<	<	<	<	<	<	<
malathion	<	<	<	<	<	<	<	<	<	<	<
MCPA (4-chloro-2-methylphenoxy-acetic acid)	<	<	<	<	<	<	<	0.06	<	<	0.02
mecoprop (MCPP)	<	<	<	<	<	<	<	0.06	<	<	0.03
methabenzthiazuron	<	<	<	<	<	<	<	<	<	<	<
methomyl	<	<	<	<	<	<	<	<	<	<	<
metobromuron	<	<	<	<	<	<	<	<	<	<	<
metoxuron	<	<	<	<	<	<	<	<	<	<	<
naphtalene	<		0.01		<	0.01	0.03	0.05			
oxamyl	<	<	<	<	<	<	<	<	<	<	<
parathion-ethyl	<	<	<	<	<	<	<	<	<	<	<
parathion-methyl		<	<	<	<	<	<	<			
pentachlorophenol		<	<	<	<	<	<	0.03	<	<	<
propazine	<	<	<	<	<	<	<	<	<	<	<
propoxur	<	<	<	<	<	<	<	<	<	<	<
pyrazophos	<	<	<	<	<	<	<	<	<	<	<
simazin	0.01	<	<	<	<	<	0.01	0.02	<	0.01	0.02
TCA (trichloroacetic acid)	0.3		0.1		0.36	<	0.18	0.36			
terbutylazine	0.01	0.02	<	<	<	<	0.01	0.03	<	0.01	0.02
2,4,5-trichlorophenol		<	<	<	<	<	<	<	<	<	<
2,4,6-trichlorophenol		<	<	<	<	<	<	0.01	<	<	<

Pesticides and other substances in the Rhine water at Lobith during 2000

Supplement 6B

(monthly averages and index numbers)

Parameter	unit	n	d.l.	Jan.	Feb.	Mar.	Apr.	May	June	July
aminomethylphosphonic acid (AMPA)	µg/l	13		0.15	0.10	0.16	0.27	0.11	0.30	0.40
atrazine	µg/l	13	0.01	0.01	<	<	0.03	0.06	0.23	0.10
azinphos-methyl	µg/l	3	0.01	<	<	<				
bentazon	µg/l	13	0.030	<	<	<	<	<	0.030	<
carbaryl	µg/l	10	0.01	<	<	<	<	<	<	<
chlorofenvinfos	µg/l	13	0.01	<	<	<	<	<	<	<
chlorotoluron	µg/l	13	0.050	<	<	<	<	<	<	<
2,4-D (2,4-dichlorofenoxy-acetic acid)	µg/l	13	0.020	<	<	<	<	<	<	<
dalapon (2,2-dichloropropionic acid)	µg/l	6	0.10			<				<
diazinone	µg/l	13	0.01	<	<	<	<	<	0.01	<
dichloroprop (2,4-DP)	µg/l	13	0.020	<	<	<	0.020	0.030	<	<
1,2-dichloropropane	µg/l	13	0.01	<	<	<	0.02	0.01	<	<
1,3-dichloropropane	µg/l	13	0.01	<	<	<	<	<	<	<
cis 1,3 dichloropropene	µg/l	13	0.01	<	<	<	<	<	<	<
trans 1,3 dichloropropene	µg/l	13	0.01	<	<	<	<	<	<	<
dichlorovos	µg/l	13	0.00	<	<	<	<	<	<	<
dimethoate	µg/l	13	0.05	<	<	<	<	<	<	<
2,4-dinitrophenol	µg/l	13	0.20	<	<	<	<	<	<	<
dinoseb (2-sec.butyl-4,6-dinitrophenol)	µg/l	13	0.03	<	<	<	<	<	<	<
dinoterb (2-tert.butyl-4,6-dinitrophenol)	µg/l	13	0.03	<	<	<	<	<	<	<
diuron	µg/l	13	0.050	<	<	<	<	<	0.050	0.070
DNOC (2-methyl-4,6-dinitrophenol)	µg/l	13	0.02	<	<	<	<	<	<	<
α-endosulfan	µg/l	7	0.010	<		<		<		<
glyphosphate	µg/l	13	0.05	<	<	<	0.11	<	0.09	0.06
hexachloro benzene (HCB)	µg/l	7	0.010	<		<		<		<
α-HCH (α-hexachloro cyclohexane)	µg/l	7	0.010	<		<		<		<
isoproturon	µg/l	13	0.050	<	<	<	0.120	<	<	<
lindane	µg/l	7	0.010	<		<		<		<
linuron	µg/l	13	0.050	<	<	<	<	<	<	<
malathion	µg/l	13	0.01	<	<	<	<	<	<	<
MCPA (4-chloro-2-methylphenoxy-acetic acid)	µg/l	13	0.020	<	<	<	<	<	<	<
mecoprop (MCPP)	µg/l	13	0.020	<	<	<	0.020	0.020	<	<
methabenzthiazuron	µg/l	13	0.010	<	<	<	<	<	<	<
metobromuron	µg/l	13	0.050	<	<	<	<	<	<	<
metoxuron	µg/l	13	0.050	<	<	<	<	<	<	<
naphtalene	µg/l	8	0.05	<		<		<	<	<
parathion-ethyl	µg/l	13	0.01	<	<	<	<	<	<	<
parathion-methyl	µg/l	13	0.01	<	<	<	<	<	<	<
pentachlorophenol	µg/l	11	0.01	<	<	<	<	<	<	<
propazine	µg/l	13	0.01	<	<	<	<	<	<	<
pyrazophos	µg/l	13	0.01	<	<	<	<	<	<	<
simazin	µg/l	13	0.01	<	<	<	<	0.02	0.02	0.03
TCA (trichloroacetic acid)	µg/l	6	0.10			0.15				<
terbutylazine	µg/l	13	0.01	<	<	<	<	<	0.02	0.03
2,4,5-trichlorophenol	µg/l	11	0.01	<	<	<	<	<	<	<
2,4,6-trichlorophenol	µg/l	11	0.01	<	<	<	<	<	<	<

n	number of observations during the year under review	min.	minimum
d.l.	detection limit	av.	average
10%, 50%, 90%	10%, 50%, 90% of the measurements are beneath the reported value	max.	maximum

Parameter	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**	min.	av.	max.	10%	50%	90%
aminomethylphosphonic acid (AMPA)	0.28	0.39	0.34	0.20	0.23	0.10	0.25	0.40	0.11	0.27	0.36
atrazine	0.03	0.02	0.02	0.01	<	<	0.04	0.23	<	0.02	0.06
azinphos-methyl						<	<	<			
bentazon	<	<	<	<	<	<	<	0.030	<	<	<
carbaryl	<	<			<	<	<	<	<	<	<
chlorofenvinfos	<	<	<	<	<	<	<	<	<	<	<
chlorotoluron	<	<	<	0.072	<	<	<	0.120	<	<	<
2,4-D (2,4-dichlorofenoxy-acetic acid)	<	<	<	<	<	<	<	<	<	<	<
dalapon (2,2-dichloropropionic acid)			<	<	<	<	<	<			
diazinone	<	<	<	<	<	<	<	0.01	<	<	<
dichloroprop (2,4-DP)	<	<	<	<	<	<	<	0.030	<	<	<
1,2-dichloropropane	<	0.06	<	<	<	<	0.01	0.06	<	<	0.01
1,3-dichloropropane	<	<	<	<	<	<	<	<	<	<	<
cis 1,3 dichloropropene	<	<	<	<	<	<	<	<	<	<	<
trans 1,3 dichloropropene	<	<	<	<	<	<	<	<	<	<	<
dichlorovos	<	<	<	<	<	<	0.01	<	<	<	<
dimethoate	<	<	<	<	<	<	<	<	<	<	<
2,4-dinitrophenol	<	<	<	<	<	<	<	<	<	<	<
dinoseb (2-sec.butyl-4,6-dinitrophenol)	<	<	<	<	<	<	<	<	<	<	<
dinoterb (2-tert.butyl-4,6-dinitrophenol)	<	<	<	<	<	<	<	<	<	<	<
diuron	<	<	<	<	<	<	<	0.070	<	<	<
DNOC (2-methyl-4,6-dinitrophenol)	<	<	<	<	<	<	<	<	<	<	<
α-endosulfan		<		<	<	<	<	<			
glyphosphate	0.05	0.07	0.09	<	<	<	0.05	0.11	<	0.05	0.09
hexachloro benzene (HCB)		<		<	<	<	<	<			
α-HCH (α-hexachloro cyclohexane)		<		<	<	<	<	<			
isoproturon	<	<	<	0.095	<	<	<	0.120	<	<	0.070
lindane		<		<	<	<	<	<			
linuron	<	<	<	<	<	<	<	<	<	<	<
malathion	<	<	<	<	<	<	<	<	<	<	<
MCPA (4-chloro-2-methylphenoxy-acetic acid)	<	<	<	<	<	<	<	<	<	<	<
mecoprop (MCPP)	<	0.030	<	<	<	<	<	0.030	<	<	0.020
methabenzthiazuron	<	<	<	<	<	<	<	<	<	<	<
metobromuron	<	<	<	<	<	<	<	<	<	<	<
metoxuron	<	<	<	<	<	<	<	<	<	<	<
naphtalene		<		<	<	<	<	<			
parathion-ethyl	<	<	<	<	<	<	0.02	<	<	<	<
parathion-methyl	<	<	<	<	<	<	0.02	<	<	<	<
pentachlorophenol	<	<	<	<		<	<	<	<	<	<
propazine	<	<	<	<	<	<	<	<	<	<	<
pyrazophos	<	<	<	<	<	<	0.04	<	<	<	<
simazin	<	<	0.01	<	<	<	<	0.03	<	<	0.02
TCA (trichloroacetic acid)			<	0.11	<	<	<	0.18			
terbutylazine	<	0.02	<	<	<	<	<	0.03	<	<	0.02
2,4,5-trichlorophenol	<	<	<	<		<	<	<	<	<	<
2,4,6-trichlorophenol	<	<	<	<		<	<	<	<	<	<

Alarm reports

Supplement 7A

Incidental contaminations of the Rhine in 1999 recorded by the N.V. WRK in Nieuwegein (central RIWA alarm post)

No.	Date	Location	Str.km	Type of contamination/quantity	Conc.	Cause/Source
1	15/02	Rhine, Ludwigshafen	430	methylglyoxal, approx. 600 kg	9 µg/l	incorrect cooling water discharge
2	21/02	Rhine, Dornick	847	potassium chloride, 200-500 tons	230 mg/l	accident on board ship
3	31/03	Rhine, Bimmen	865	orthoxylol	2-9 µg/l	unknown
4	02/04	Upper Rhine and Waal, Lobith	867	isoproturon	1.03 µg/l	unknown
5	11/04	Rhine, Pratteln (Basel)	156.9	various buthylated phenols Rheinfelden measuring station	intake duration 13 hours	discharge chemical industry
6	21/04	Rhine, random sample at Büderich	812	benzene styrene	50 µg/l 5 µg/l	unknown
7	07/05	Rhine, Dormagen	710.6	petrol, 950 m^3, nitrous acid		accident on board with the “Avanti”
8	07/05	Rhine, Zons	717	toluene		accident “Avanti”
9	08/05	Rhine, Lobith	867.6	ethylbenzene	56-8.5 µg/l	accident “Avanti”
10	09/05	Lower Rhine, Amerongen	917	ethylbenzene meta/paroxylene orthoxylene C3-benzenes toluene benzene	53 µg/l 25 µg/l 10 µg/l 14 µg/l 1.2 µg/l 0.05 µg/l	result of accident on board with the “Avanti”
11	28/05	Rhine, Bad Honnef, measuring station random sample	640	benzene	12.6 µg/l	unknown
12	11/06	Rhine, Duisberg-Voerde	769-800	diesel fuel	unknown	salvage “Avanti”
13	22/06	Rhine, Düsseldorf, station Rathauser	744.5	ethylxylene m+p-xylene o-xylene various xylenes	1.6 µg/l 6.0 µg/l 1.2 µg/l	unknown
14	10/07	Rhine, Holthausen-Bimmen	730-865	xylene, toluene, benzene		unknown discharges
15	21/07	Rhine, Ludwigshafen	433.2	trimethylcyclohexenone	800 kg	failure BASF
16	06/11	Rhine, Ludwigshafen	433.2	tert. butanol, (2-methyl-2-propanol)	800 kg	failure BASF
17	06/11	Rhine, Nieder-Walluf-Gelsenheim	507-523	mineral oil, trail about 16 km		unknown
18	29/11	Rhine, Cologne	694-703	oil, trail about 5.5 km		unknown discharge

Alarm reports

Supplement 7B

Incidental contaminations of the Rhine in 2000 recorded by the N.V. WRK in Nieuwegein (central RIWA alarm post)

No.	Date	Location	Str.km	Type of contamination/quantity	Conc.	Cause/Source
1	01/28	Rhine, Büderich	812	styrene, unknown	5.7 µg/l	unknown
2	02/22	Rhine, Weil am Rhein	171	butoxy ethylacetate, unknown	7.8 µg/l	unknown
3	05/17	Rhine, Ludwigshafen	433	isononanol, approx. 1000 kg	approx. 8 µg/l	BASF purification installation leakage
4	05/26	Rhine, Basel	168	diesel fuel, 10,000-15,000 l	unknown	accident on board
5	06/11	Rhine, Krefeld	768	purification sludge, unknown	unknown	purification installation failure
6	06/13	Rhine, Kleve	865	benzene, unknown	23 µg/l	unknown
7	07/22	Rhine, Basel	168	sec. bumeton, unknown	1.2 µg/l	unknown
8	07/26	Rhine, Karlsruhe	362	sec. bumeton, unknown	0.12 µg/l	unknown
9	09/03	Rhine, Bimmen	865	1.2 dichloropropane, < 3020 kg	8.1 µg/l	unknown
10	10/09	Rhine, Düsseldorf	728	floating oil film, 100000 m^2	unknown	unknown
11	10/20	Rhine, Karlsruhe	360	diesel fuel, unknown	unknown	unknown
12	12/07	Rhine, Wesseling (Cologne)	668	diesel, unknown	unknown	leaking vessel

Communiqué 13th Rhine Conference of ministers (ICBR-treaty nations)

Supplement 8

January 29, 2001, Strasbourg

The members of the International Commission for Protection of the Rhine (ICBR) convened at ministerial level on January 29, 2001, in Strasbourg, with Mrs. Voynet, the Minister of Spatial Planning and the Environment in France, as chairperson.

The following persons participated in the conference:

For Germany, Mr. Dr.-Ing. E.h. Dietrich RUCHAY, Director general, on behalf of Mr. Jürgen Trittin, Federal Minister of the Environment, Nature Protection and Nuclear Reactor Safety
For France, Mrs. Dominique VOYNET, Minister of Spatial Planning and the Environment
For Luxembourg, Mr. Paul HANSEN, Director of the Environmental Agency, on behalf of Mr. Michel Wolter, Minister of the Interior
For the Netherlands, Mrs drs. Monique de VRIES, Assistant Minister of Transportation and Public Works
For Switzerland, Mr. Philippe ROCH, Assistant Minister, Director of the Federal Agency for the Environment, Forestry and Landscape
For the European Commission, Mr. Prudencio Parera MANZANEDO on behalf of Mrs. Margot Wallström, Commissioner for the Environment
For the International Commission for Protection of the Rhine, Mr. Adriaan JACOBOVITS DE SZEGED, Commission Chairman

As observers

For the Wallonian Province, Mrs. Anne TRENTELS on behalf of Mr. Michel Foret, Minister for Spatial Planning, Urban Construction and the Environment.

Representatives of intergovernmental and non-governmental organisations

The Ministers from the ICBR Treaty nations (Germany, France, Luxembourg, the Netherlands and Switzerland) responsible for the protection of the Rhine held a meeting on January 29, 2001, in Strasbourg, in order to discuss the most important results of the measures taken to protect the Rhine in the past 50 years and to arrive at new proposals for further co-operation.

The Ministers and the European Commission draw the attention to the considerable improvement of the water quality and to the progress made in the ecological recovery of the ecosystem along the Rhine. They are especially pleased with the success of the various measures taken to protect the Rhine, such as the Rhine Action Program and the "Salmon 2000" program, which were both concluded in 2000.

Considered as a whole, it may be established that contamination from point sources (industry and municipalities) is well under control. According to the status report presented at the conference, the great majority of the substances no longer pose a problem if the objectives which apply to the Rhine are taken into consideration. Efforts to reduce discharges from diffuse sources were less successful, with the result that the share of diffuse discharging in the total discharge has increased for nutrients and heavy metals. The biodiversity in the Rhine has also clearly improved. By installing fish ladders and due to the measures taken to improve the river landscape (e.g. due to nature recovery in the water meadows and restoring the natural course of parallel channels of the Rhine) the conditions were created for giving rise to the fact that most of the 45 fish species characteristic for the Rhine and 38 water bird species living on and along the Rhine can be observed nowadays just like at the end of the 19th century.

The Ministers of the European Commission are pleased to hear that Europe's biggest fish ladder in Iffezheim was put into operation in the summer of 2000 and is operating to full satisfaction. Therefore, they will make an effort to have the installation of the fish ladder in Gambsheim, already agreed upon, implemented as soon as possible.

According to the report on the first phase of the implementation of the High Water Action Plan, presented at the conference, the objectives through 2000 have by and large been met. However, special attention should be given to the intended reduction of damage risk in flood areas and in areas threatened by high water. Although by now all ICBR nations have a legal and planological framework available to protect flood areas and to limit their use, it was, for example, not yet possible to put an halt to further construction in these areas. It is necessary that the public be made aware of these problems to a greater extent. Ambitious objectives also apply to the following phase, which expires in 2005, and in view of the climate change, an increase in the high water risk is ever more probable. The Ministers and the European Commission therefore again emphasise the necessity of realising the High Water Action Plan within the period intended. They ask all those in charge to also assign high priority to taking the necessary measures, even in times of limited financial means. The ICBR High Water Action Plan, in which measures with a total volume of approximately 12 billion euros have been planned for the period through 2020, also contributes to the further improvement of the ecological situation of the Rhine and its tributaries. The Ministers and the European Commission give their approval to the program of durable development of the Rhine, in which an ambitious policy to protect the Rhine has been established for the period through 2020 on the basis of these objectives. The guidelines of the Rhine Conference for Ministers on January 22, 1998 in Rotterdam form the basis of this program.
A provisional Work plan through 2005 is drawn up at the ICBR. The Conference of Ministers appeals to the ICBR to approve this Plan in the next plenary meeting after consultation with regional (semi) governments and other boards involved from every nation.
This plan will be part of the co-ordinated control plan for the Rhine watershed, yet to be drawn up.

The remaining objectives with respect to the Rhine watershed, established in the “Rhine 2020” program and which meet the requirements of the Water Framework Directive or exceed these in the areas of ecology and high water protection, include further reduction of discharges (especially discharges originating from diffuse sources), protection of the groundwater in interaction with the Rhine, safeguarding a balance between extraction of groundwater and creation of new groundwater, realising a biotope complex along the Rhine from the Lake of Konstanz to the North Sea, including recovery of the ecological passability and raising the debit of parallel channels, integration of high water prevention and improvement of the ecosystem and, last but not least, a higher degree of public involvement by means of new types of information provision and participation. This program provides the policy of protecting the Rhine, which so far has focused intensively on improvement of the water quality, with a new dimension, since the emphasis in the program for durable development of the Rhine is on the total approach in protection of the Rhine. The objectives of the program unite ecological, economic and social aspects in a balanced manner. Realisation of this also contributes to the fact that contamination by priority-hazardous substances, as referred to in the framework of the Treaty concerning protection of the marine environment in the north-eastern part of the Atlantic Ocean (OSPAR), will be halted.

The Ministers and the European Commission are pleased to find out that the information exchange with the non-government organisations has meanwhile developed into a fixed component of ICBR operations.

The Ministers and the European Commission also call attention to the fact that the long demanded harmonisation and re-orientation of the community water policy has been complied with by the directive of the European Parliament and the European Union Council for establishing a framework for community measures related to the water policy (Water Framework Directive) which recently took effect. Comparable objectives are pursued with the “Rhine 2020” program and the Swiss legislation. In view of this background, the measures planned in accordance with the “Rhine 2020” program can serve as a basis for the measure programs which must be drawn up by the EU member states by virtue of the Water Framework Directive.

The Ministers and the European Commission are pleased with the agreement reached by all nations in the Rhine watershed on the approach to drawing up a co-ordinated control plan for the entire international Rhine watershed in correspondence with the Water Framework Directive, and they agree with the fact that the ICBR secretariat provide logistical support to the appointed steering group within the limits of the available capacity.

The Ministers and the European Commission are satisfactorily acquainted with the fact that the ratification of the new Rhine Treaty of April 12, 1999 by the parties participating in the treaty are making good progress and indicate their wish that the treaty take effect as soon as possible.

Finally, they emphasise the tangible success of international co-operation within the ICBR and will ensure that the co-operation in the area of protection of the Rhine will be continued in the same climate of trust and with the same efficiency as in the past few decades.

Communiqué 13th Rhine Conference of ministers (Rhine watershed states)

Supplement 9

January 29, 2001, Strasbourg

The Ministers responsible for protection of the water in the Rhine watershed and the European Commission convened on January 29, 2001, in Strasbourg, with Mrs. Voynet, the Minister of Spatial Planning and the Environment of France, as chairperson.

The following persons participated in the conference:

For Germany, Mr. Dr.-Ing. E.h. Dietrich RUCHAY, Director general, on behalf of Mr. Jürgen Trittin, Federal minister of the Environment, Nature Protection and Nuclear Reactor Safety
For France, Mrs. Dominique VOYNET, Minister of Spatial Planning and the Environment
For Liechtenstein, Mr. Dr. Norbert MARXER, Minister of the Environment
For Luxembourg, Mr. Paul HANSEN, Director of the Environmental Agency, on behalf of Mr. Michel Wolter, Minister of the Interior
For the Netherlands, Mrs drs. Monique de VRIES, Assistant Minister of Transportation and Public Works
For Austria, Mr. Dr. Wolfgang STALZER on behalf of Wilhelm Molterer, Minister of Agriculture and the Environment
For Switzerland, Mr. Philippe ROCH, Assistant Minister, Director of the Federal Agency for the Environment, Forestry and Landscape
For Wallonia, Mrs. Anne TRENTELS on behalf of Mr. Michel Foret, Minister for Spatial Planning, Urban Construction and the Environment
For the European Commission, Mr. Prudencio Parera MANZANEDO on behalf of Mrs. Margot Wallström, Commissioner for the Environment

As observers

Representatives of intergovernmental and non-governmental organisations

The Ministers responsible for protection of the water in the Rhine watershed from Germany, France, Liechtenstein, Luxembourg, the Netherlands, Austria, Wallonia, Belgium and Switzerland as well as the European Commission are pleased with the forceful impulses to the community water policy which has the directive for establishing a framework for community measures concerning water policy (2000/60/EG) as starting point. The purpose of this directive is to introduce co-ordinated water management for each watershed, improve the water quality and involve the public in the total water policy to a greater extent.

They emphasise the importance of the water framework directive for the cross-border co-ordination in international watersheds.

They are pleased to see that the decade-long multilateral, bilateral and regional co-operation in the Rhine watershed – from the source to the mouth into the North sea – turned out to be highly successful. In this context, the results of the operations of the International Commission for Protection of the Rhine, the International Commissions for Protection of the Mosel and the Saar, the International Commission for Protection of the Bodenmeer and the International Government Commission Alpen-Rhine speak clearly for themselves.

They are informed of the fact that the ICBR has drawn up a program for durable development of the Rhine, used to pursue comparable objectives as the framework directive is intended to do, and that the other commissions will also operate in accordance with the framework directive in their programs.

Viewed against the new background of the framework directive, they assign deep significance to the co-ordinated creation of an international watershed management plan for the Rhine watershed. They would like to use the tight and efficient co-operation in the area of protection of the Rhine.

The Ministers and the European Commission emphasise that the EU member states themselves are responsible for implementation of the directive and that they consider a co-ordinated approach in the Rhine watershed necessary.

In their pursuit of meeting the objectives and time schedule with respect to implementation of the framework directive in an effective manner, the Ministers and the European Commission decide to continue the existing co-ordinating operations and to maintain the structures set up in the form of a steering group.

This steering group is made up of national government representatives and other national/regional representatives. The chairmanship of the steering group is rotated among the EU member states in the Rhine watershed. The above-mentioned international commissions can be involved as observers.

The steering group will co-ordinate the operations that are necessary at the level of the entire watershed in order to effect a coherent application of the directive and creation of an international watershed management plan for the Rhine watershed.

The Ministers and the European Commission are pleased with the decision of Switzerland to have itself represented as a non-EU-member nation in the steering group and to support the steering group in its co-ordinating and harmonising operations on the basis of its legislation, expressing in this way its desire to co-operate with the European Union in the area of water policy.

The Ministers and the European Commission commission the steering group to investigate which means and which other organisational measures are necessary for implementation of the co-ordinating operations. They will also, as soon as this becomes necessary, investigate the modalities for financing the communal operations which are necessary for creation of the co-ordinated watershed management plan. They will especially take into account that not all Rhine bank states are obligated to implement the framework directive. They are pleased with the ICBR offer to have the ICBR secretariat provide the steering group with logistical support, within the limits of the capacity available.

The Ministers and the European Commission express their wish that their approach to the Rhine watershed serve as an example in implementing the framework directive.

Colophon

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