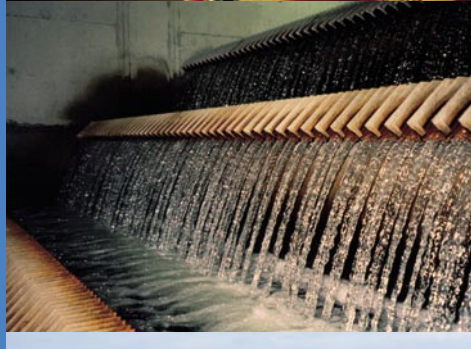
Drinking Water

Principles and Practices



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kiwa
Partner for progress

TU Delft
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DRINKING WATER
Principles and Practices

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Preface

Drinking water: the miracle from the tap

For many people drinking water is something we usually do not think about and don't know much about either. We open the tap and clean and fresh drinking water pours out. We take it for granted. We know the water quality is excellent and that it is actually not necessary to buy bottled water. Nevertheless, we sometimes read in the newspaper alarming articles about the pollution of our drinking water sources. How does that happen? How do the drinking water companies actually purify our drinking water, and will they continue in the future? Similarly, there are several other questions people sometimes ask about our drinking water:

- Why do we flush our toilet with clear and costly drinking water?
- Is our water "hard" and should we believe the commercials about water softeners?
- Which elements does water actually contain?
- Is drinking water healthy?
- Can you purify water with your own filters?
- Is it safe to drink rainwater?
- How is the quality of our drinking water being safeguarded?
- Is groundwater abstraction responsible for the deterioration of national parks?
- What is the function of a water tower?
- What do the drinking water companies do in restricted areas and in national parks?

Students who follow courses in drinking water at Delft University of Technology also have these questions.

For whom is this book meant?

This book contains the course material about drinking water for students in the Bachelor of Science program (BSc) of Civil Engineering at Delft University of Technology.

In these courses the students acquire a broad view of the drinking water service. Not just the theoretical principles, but also the practical operation of drinking water companies. Not just the techniques, but also the historical background, the judicial arrangements, the financial aspects, the global situation, etc.

The course material should give all Civil Engineering students a vast and sound base, which can be used in their future profession. For students who will specialize in the Master of Science program (MSc), the course material will provide a basis for specialist courses like "Drinking water production" and "Drinking water distribution."

The course material follows a modular structure and emphasizes independent learning. That makes this course material also very suitable for many others: from students seeking a higher professional education, to people who are involved in one way or another in the drinking water service, to the drinking water consumers who would like to know more about "the miracle from the tap."

How is the book structured?

The modern student is an independent learner, meaning that time and planning are much more determined by the student himself than by the course schedule. Modern course materials are adapted to this.

This book consists of ten independent modules. All modules follow a uniform design. First, there is a page of information about the module under the headings of "Framework," "Contents," and "Study goals." Next,

the actual learning material (contents) is presented. Following that is a list of recommended literature and websites. Because of the broad character of the course material, a list of references is not included. Finally, questions and answers are presented. The questions challenge the students' recall of the material read, the applications ask students to put their understanding to use.

Courses from this book

Because of the module structure, this book can be used as teaching and learning material for different courses in drinking water supply. Each module can be used independently, but also in courses dealing with specific focus points. Examples of such courses can be given as:

Module / Course	Sanitary Engineering	Amsterdam water	Drinking water companies	Planning and design	Finances	Water consumption	Water quality	Groundwater	Surface water	Distribution
Basic short course	●	●	●							
Design			●	●	●					
Water treatment			●				●	●	●	
Water distribution			●			●				●

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prof. ir. J.C. (Hans) van Dijk

Delft, April 2006

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Detailed contents (per module)

Public water

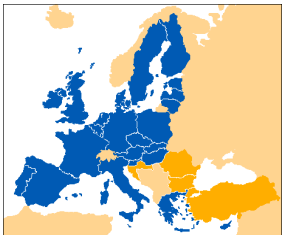
Water companies

ADDENDUM

Drinking water and the Netherlands

Student questions

All our foreign students are putting the same question on the table:
"How do we benefit from studying the Dutch water supply?"
We are used to giving them the following answer:
"The Netherlands has developed the most highly respected drinking water infrastructure in the world, so you not only learn the most sophisticated and modern techniques, but also you learn from 150 years of experiences, from the successes and, especially, from the failures on the road to that high ranking."



150 years of history
Focus on public health
100% coverage
Regional supply areas
Private companies
Publicly owned
Cooperation in research

Environmental watchdog
Protected sources
Safe groundwater
Artificial groundwater
Multiple barriers

No chlorine
No hard water
No fluoride
No pesticides
No home filters
No bottled water
No leakage
No wasting water

Most often, they come up with the second question:
"Can you give us, in a few words, what makes this infrastructure so special and worthwhile to study?"
For this we typically come up with the following explanation:
"Between 1853 and 1970 everyone in the Netherlands was connected to a piped water supply system.
"Public health was the leading focus since the early 1900s. It was the motivating factor for establishing public water systems in the country, and for connecting even the most remote houses to the public water system. The concern for public health still dominates the Dutch drinking water culture which is reflected in the technical, institutional and legal policies and regulations.
"With the Water Supply Act of 1957, the many small water supply companies were consolidated into regional public companies. Now, we have 11 drinking water companies, which are fully publicly owned, and the focus is still on public health.
"Nearly the entire present situation can be understood from this focus on public health and the ongoing concern for high quality drinking water. What we can applaud is the extensive cooperation in research, the use of safe groundwater when available, the use of artificial groundwater, the use of surface water with "multiple barriers," water treatment without chlorine, the supply of softened water, the very low leakage in the distribution system, etc.
"The high quality standard of the Dutch public tap water has resulted in a few remarkable developments. Examples of these are the very low sales of bottled water, the effectiveness of water-savings programs (in a country which abounds in water), and the ban on fluoride. All this shows the Dutch citizens' appreciation for their tap water."

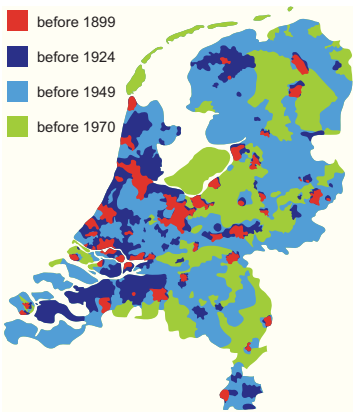
This answer makes the students interested in knowing more. Modern students do not blindly accept what their professors tells them, so their next query is:
"Can you show me that all these statements hold true, with facts and figures?"
That is when we take our books and reports and show them the following:

Full coverage took 100 years ...

Piped drinking water in the Netherlands started in 1853 when the Amsterdam water supply system came into operation.
Between 1874 (now in Rotterdam and The Hague) and 1920, piped drinking water became available in all Dutch cities and towns, via municipalities or private water supply companies. By that time some 48% of the population lived in houses connected to a piped drinking water system.

Period	Focus
1853-1920	Cities and towns
1921-1950	Villages
1951-1970	Remote area's

Introduction of piped water systems

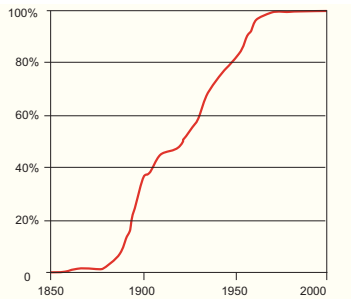


Coverage of piped water (VEWIN)

Between 1920 (in North Holland) and 1950, regional water companies were established, which provided drinking water to the villages. By that time some 82% of the total population had a house connection.

Between 1950 and 1970, these regional water companies were financially supported by the central government to help cover the cost to connect the houses in remote areas, thus bringing the house connection coverage to 99%.

It should be noted that the Dutch population increased from 3.1 million in 1853 to 13.0 million in 1970. This means that most house connections were made in newly built residential areas.



Houses supplied by piped water (VEWIN)

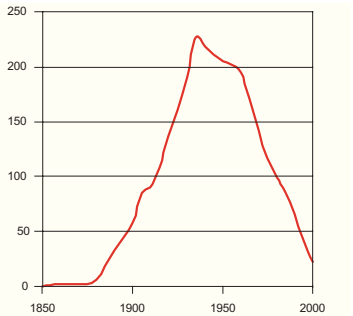
At present all houses are connected, providing drinking water to 16.3 million inhabitants.

... and merging into regional companies took 50 years

The water supply for the cities and towns was locally developed by separate private and municipal companies. In 1910 there were 90 different drinking water companies, about 55% were private and about 45% municipal.

The number of drinking water companies was at its peak in 1938, when 228 (mostly municipal) water companies were active.

In 1957 the Water Supply Act was accepted by the Dutch parliament. One of its major goals was to strengthen the water supply sector by merging the companies into provincial public drinking water companies.
Under this law, the number of water supply companies has decreased to 11 in 2006.



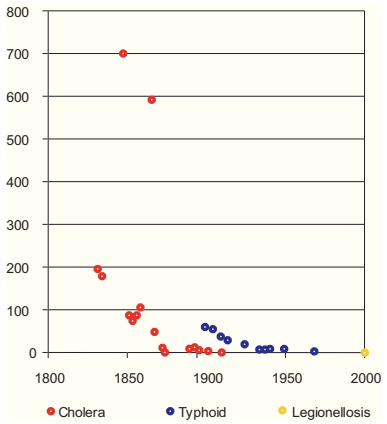
The number of drinking water companies. First locally and small, afterwards merging into a few large companies (VEWIN)

Public health as driving force ...

In a "Report to the King" (1868), it was concluded that a piped water supply was essential for improving public health. It further stated that the central government should enforce the development of municipal and private water supply companies, and should supervise the drinking water quality.

Defeating Cholera required a water supply in the urban areas. To defeat Typhoid, the rural areas also had to be provided with safe drinking water.
Since 1999, Legionellosis has been recognized as an important public health issue related to water systems with elevated temperatures.

During the last 50 years, the environment has become more polluted, requiring additional water quality regulations, as well as more advanced treatment techniques.



Mortality per 100,000 person in the Netherlands by drinking water related diseases (RIVM)

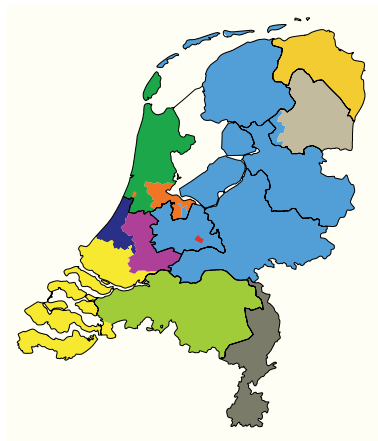
Yearly, the National Institute for Public Health and the Environment ("Rijksinstituut voor Volksgezondheid en Milieuhygiëne – RIVM") reports to the Dutch government on drinking water quality in the Netherlands.

... for publicly owned private companies ...

All but two drinking water companies in the Netherlands are publicly owned private companies. These companies are managed quite autonomously according to business principles, but are controlled by their public shareholders. Contrary to private companies, their shares can only be owned by municipalities and/or provinces ("public companies").
The companies are full-cost recovering without any municipal or governmental subsidies.
The companies operate on a "not for profit" basis, without paying dividends to their shareholders.

The city of Amsterdam's water is supplied by a municipal water company, which functions in a more or less similar way.
The village of Doorn is supplied by a private company.

As part of the European doctrine on privatization, the ownership of drinking water companies was discussed in the late nineties.
In 1999 the Dutch government decided that water services would remain in public hands in view of the important role of the drinking water companies in public health and the environment.



From 225 in 1938 down to 11 water companies in 2006, and still merging (TU Delft)

... with joined efforts in research and public education ...

The shared focus on public health and the absence of commercial competition was, and is, a sound basis for intensive cooperation between the water companies. Moreover, such collaboration is in line with the century-old Dutch tradition of the joined struggle against the water from the sea.

Additionally, the short travel distances in the Netherlands were and are a boon to information exchanges.

In 1899 the Royal Association of Drinking Water Supply in the Netherlands (KVWN) was founded as a multi-disciplinary body of people. It is the oldest association in the field of drinking water supply in the Netherlands, and is still noticeably active (1,400 members).

The KVWN was the birthplace of organizations such as VEWIN, Kiwa, Wateropleidingen, Aqua for All and others.

The Netherlands Ministry of Housing, Spatial Planning and the Environment (VROM) is responsible for the Dutch drinking water supply.

VROM uses the National Institute for Public Health and the Environment (RIVM) for its research on health issues, as well as for (independent) drinking water quality control.

VROM and RIVM are working in close cooperation with the drinking water sector.

The Association of Dutch Water Companies (VEWIN) is the association for all drinking water companies in the Netherlands (except the private company of Doorn).

VEWIN is the voice of the water companies, both to the public as well as to the Dutch and European governments. VEWIN employs almost 30 people and has a yearly budget of over € 5 million.

The water supply companies of the Netherlands founded Kiwa, for quality control of all equipment related to drinking water (pipes, meters, etc.).

In addition, Kiwa Water Research carries out the joint research program as defined by the water companies (€ 6 million per year). In this research, Kiwa works with TU Delft, as well as with international partners including Unesco-IHE, AWWARF, UKWIR, TZW, CRC, Veolia and Ondeo.

... and open information to the public

The Dutch drinking water companies maintain open communication with the public. All water companies publish annual reports and include technical and financial information. The Waterleidingstatistiek gives the yearly statistics of the water companies (since 1902). RIVM reports yearly on the drinking water quality (since 1992).

The efficiency of the drinking water companies is publicly evaluated with the VEWIN benchmark (every 3 years).

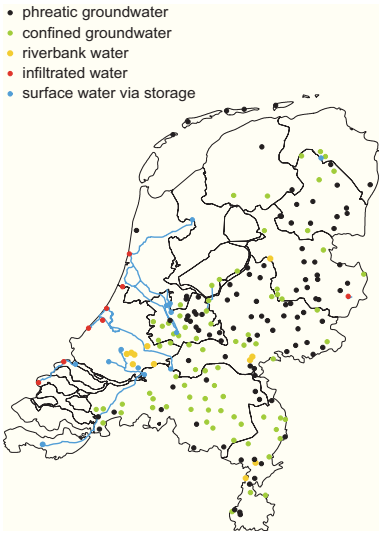
Safe groundwater when available ...

Groundwater is the preferred source for the production of drinking water in the Netherlands.
Groundwater in the Netherlands is free of pathogenic organisms, and therefore usable without disinfection. Moreover, it has a consistent good quality and a constant pleasant temperature.

Groundwater in the Netherlands is abstracted within restricted areas, where land use is regulated. Land in the immediate neighborhood of the abstraction wells is owned by the water companies.
Water from outside the restricted areas will take at least 25-50 years to arrive at the abstraction wells.
These large areas (in total some 1,500 km^2, 4.4% of the land area in the Netherlands) allow adequate protection and a very long response time in case of a groundwater contamination.

Source	Number of locations	Abstraction (million m^3)
Groundwater (natural)	192	709
Artificial groundwater (riverbank filtration)	12	61
Artificial groundwater (dune infiltration)	7	214
Surface water (reservoirs)	7	293
Total	218	1,277

Different sources for drinking water production in the Netherlands in 2004 (VEWIN/RIVM 2004)



At more than 30-40 km from the sea, fresh groundwater is available for drinking water production (RIVM 2004)

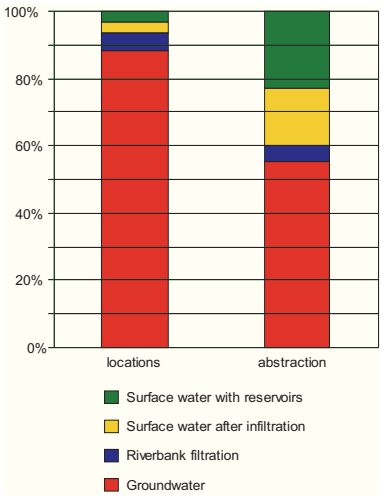
... or artificial groundwater ...

The available quantity of groundwater is insufficient for the total drinking water needed. Therefore, availability is increased by infiltrating surface water into aquifers along the North Sea coast and major rivers. In this way, surface water is converted into "artificial groundwater," yielding the above mentioned benefits of groundwater (safe, constant, and reliable).

Some 20% of the Dutch drinking water comes from artificial groundwater abstracted in the dunes.

Infiltration ponds in the dunes along the North Sea coast at The Hague

The infiltration of pretreated surface water in unconfined aquifers is unique in the world. This system enables more than a 10-fold capacity in the same abstraction area compared to natural groundwater. It provides a natural filter for pathogenic bacteria and viruses, a constant water quality and temperature, and a large storage reservoir to overcome pollution waves in the river.



Nearly 80% of the Dutch drinking water comes from groundwater (and artificial groundwater) (VEWIN/RIVM 2004)

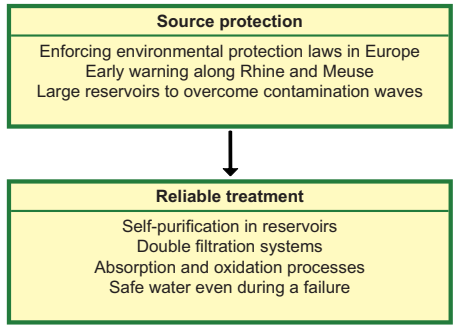
To a smaller extent, use is made of artificial groundwater along the rivers (riverbank filtration). This system is more widely used in Germany where coarser aquifers are found.

The modern variant is reservoir bank filtration. This combines the simplicity of riverbank filtration with the reservoir advantage of interrupting the intake during contamination waves.

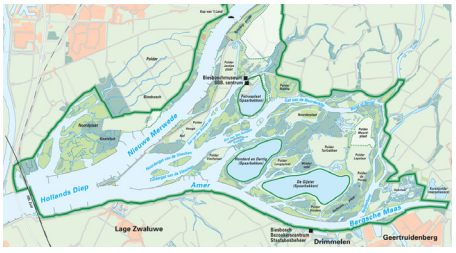
Reservoirbank filtration along a former gravel pit near the Meuse (WML 2004)

... and surface water with "multiple barriers" ...
Around 25% of the drinking water in the Netherlands is produced directly from surface water.
Over the years these systems have had to be transformed from simple treatment systems into more complex schemes in order to cope with the increased pollution of the rivers.

Presently, the rivers Rhine and Meuse have extensive "early warning" systems.
During contamination waves, the intake in the reservoirs is interrupted.



Multiple barriers in drinking water production from surface water



Three water reservoirs in Biesbosch National Park

The most important reservoir system in the Netherlands is located in the Biesbosch National Park. The three large reservoirs provide for a residence time of several months, and storage for over a month to overcome intake interruptions.
This system provides the source for safe drinking water for over 1.5 million people in Rotterdam and surrounding regions.

... with extended treatment schemes
The treatment of surface water in the Netherlands always includes double filtration systems (dual media filtration and granular activated carbon filtration).
The water is disinfected by ozone, hydrogen peroxide and/or UV-radiation.

The Dutch drinking water is free from pesticides and low in organic material.
The treatment is so extensive that the water is biologically stable. Therefore no chlorine is needed for the distribution.

UV for disinfection at Andijk (PWN 2005)

Safe water without chlorine ...

Chlorine is not used anymore in the Netherlands for disinfection of drinking water. Worldwide, it is still the most used disinfectant by far. In 1974 Jan Rook, a chemist at Rotterdam water supply, discovered that chlorination leads to the formation of trihalomethanes, which have negative health effects.

Immediately after this discovery, the use of chlorine was reduced to the minimum. Existing treatment plants have been modified and, since 2005, chlorine is no longer used for disinfection by any treatment plant.

Alternatively, other disinfection methods have been developed and improved, such as dissolved ozone and UV/H_2O_2-systems.

Chlorine is longer used for disinfection of drinking water in the Netherlands

In order to prevent bacteriological activity in the distribution system, the Dutch water companies produce drinking water with very low content of assimilable organic carbon (AOC), and they operate the distribution systems at minimum residence times.

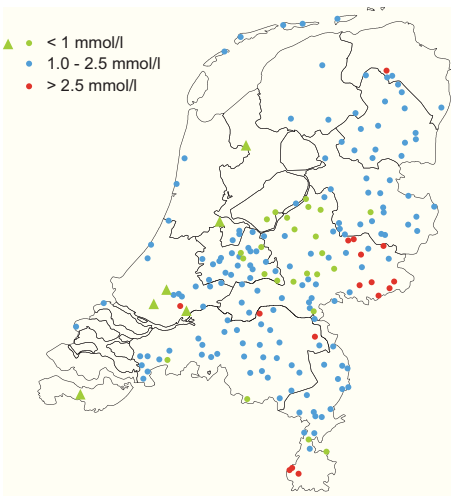
There has not been any outbreak of illness in the Netherlands related to drinking water since 1950.

... with a very low hardness ...

The Netherlands is (still) the only country in the world where the drinking water quality requirements ask for the supply of soft water (upper limit 2.5 mmol/l or 250 ppm as $CaCO_3$). This ensures water softening at many production locations.

This requirement is based on the obvious advantages of low hardness for public health and the environment, combined with comfort and economics for the consumers.

Some 50% of the drinking water is softened, either by crystallization in pellet reactors or reservoirs, by membrane filtration or by blending hard water with soft water from another location.



Softening is also planned for the few remaining locations with a total hardness above 2.5 mmol/l (RIVM 2004)).

Public health	The environment	Comfort	Economics
Less lead, copper and zinc No risky home filters	Less phosphate Less household waste water Less metals in waste sludge	Better soap while showering Better taste Better appearance (tea) Less scaling in hot water	Savings on washing powder Savings on home-filters Savings on scaling Overall lower costs

The benefits of soft drinking water are recognized in the Dutch drinking water regulations

... and without fluoride ...

Around 1960 the Dutch water supply companies investigated the possibility of dosing fluoride in the drinking water, in order to improve dental health. Many North American and Australian municipalities fluoridate their water supplies. They cite the effectiveness of this practice in reducing tooth decay, believe in the safety of fluoridation, and enjoy its low cost as well. As of 2000, around two-thirds of U.S. citizens have access to fluoridated drinking water. This fluoridation does not have the full acceptance of the general public.

Dutch people rejected the use of fluoride in drinking water

The Dutch public disapproved the dosing of fluoride in drinking water in 1974. Most European countries also rejected fluoridation.
The main reason for opposition against the fluoridation of drinking water was that it was seen as “medicine” being put in the drinking water by the government.
Caries is prevented in the Netherlands by the use of toothpaste containing fluoride and well developed dental care, which is fully sponsored for children.

... prevents the use of home filter ...

Home filters are more or less standard practice in kitchens and houses in North America and Australia.

Because of the very good quality of the Dutch drinking water, home filters are nearly completely absent in the Netherlands.
The use of home filters is considered uneconomical for consumers, and also has drawbacks on public health and the environment.

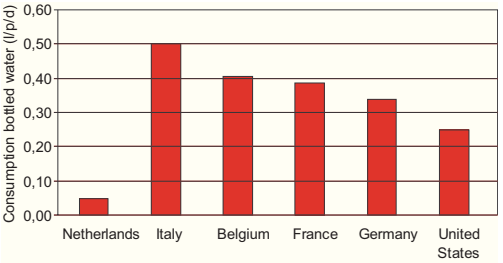
For the Dutch drinking water industry, home filters are thought to be a solution for insufficient treatment or in cases where supplying safe drinking water is technically and economically not feasible.


Dutch people drink water straight from the tap

... and results in a very low use of bottled water

Bottled water is used to a large extent in other European countries, in the United States and in Australia.

The public’s awareness of the good quality of drinking water in the Netherlands can also been seen in the very low consumption of bottled water.
Bottled water is considered expensive and unfriendly for the environment.

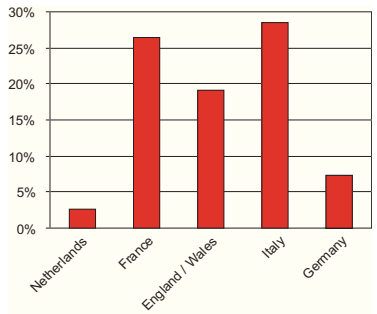


Consumption of bottled water (Bottled water reporter 2005/ VEWIN 2006)

No leakage ...

The leakage in the distribution system of the Dutch water supply companies is very low.
In part, this is achieved by the use of high quality materials (Kiwa certificated) and careful supervision during construction and repair. Also, prompt response to any reported incident, and timely replacement of old mains contributes to this figure.

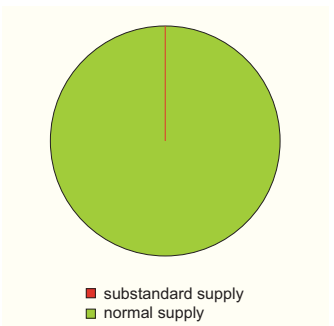
In the fully metered Dutch drinking water systems, the non-revenue water is measured as 4.6% of the input.
From this figure, the leakage, or "real losses" as reported in many other counties is estimated as some 2.5%, as part of the non-revenue water is used for flushing the distribution mains and for fire-fighting.
Illegal tapping is nearly absent.



Lowest leakage in the world (DGW 2006, VEWIN 2004).

... reliable supply systems ...

The Dutch water supply companies aim at an uninterrupted supply for their customers, 24 hours a day, 7 days a week. In practice, this goal can not completely be reached, partly because of planned maintenance in the distribution system (flushing a.o.) and partly due to unplanned breakdowns.
The mean uptime of the Dutch water supply companies is 99.9932%. This means that in a year, each connection is without adequate supply for 36 minutes per year (substandard supply minutes), on average.
Some 40% of these interruptions are planned, for which the customers have been informed in advance.

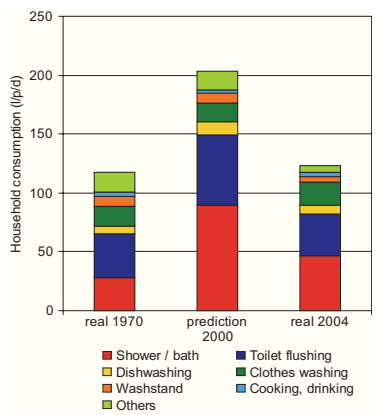


Drinking water supply with 99,9932% uptime (TU Delft 2005)

... and impressive water savings

Households consume some 65% of the total production of the Dutch water supply companies.
In 1970 this consumption amounted to 117 l/p/d (liters per person per day). Due to the increasing use of water-consuming appliances in houses, it was predicted that this consumption would increase to over 200 l/p/d, in the year 2000.

The increase in water consumption was stopped, and it actually decreased, due to the introduction of water-saving equipment, supported by extended public information programs. Important new developments are water-saving toilets, washing machines, dishwashers and showers.
At present, the actual water consumption (124 l/p/d) is nearly the same as it was in 1970, and still decreasing, after reaching its top (140 l/p/d) in 1990.



Water saving in households (Vakantiecursus 1973, VEWIN 2004)

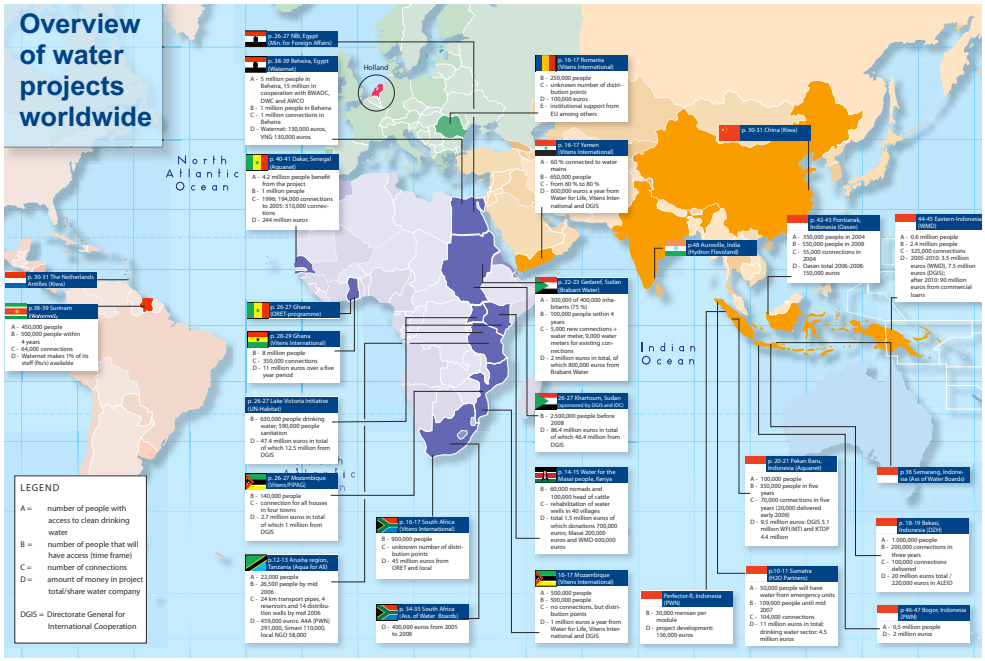
International activities of Dutch drinking water sector

The remarkable drinking water standard in the Netherlands has drawn the attention of many foreign countries.

This attention is enhanced by the extensive involvement of the Dutch drinking water sector in international institutes like WHO (RIVM), UNESCO (IHE), UNICEF (IRC) and Worldbank (BNWP), as well as its very active contribution at international research and scientific congresses (Kiwa, TU Delft).

A large part of Dutch international activities on drinking water is included in their foreign aid program. During its Presidency of the European Union, the Netherlands urged the other countries of Western Europe to raise their spending on development aid to the 0.7 percent level of its gross national product, as is done by the Dutch. Britain, France, Germany and Spain, who are now at about 0.4 percent, have adopted an accelerated timetable for reaching 0.7 percent. This means that by 2010, there will be about 42 billion euros more to spend on development aid, including drinking water facilities.

The Netherlands is the only country in the world to have drawn up output targets for water and sanitation. In the past year, contracts have been signed which will provide safe drinking water for 5.5 million people and sanitary services for 0.9 million.



Drinking water projects within the Dutch foreign aid program (VEWIN 2006)

The Dutch drinking water sector is also involved in commercial activities. For years, Dutch consulting engineers have been involved in drinking water projects around the world. Also contractors, as well as equipment and process suppliers, continue to be internationally active. Often, these private companies cooperate with Dutch drinking water companies and research institutes.

The Netherlands Water Partnership is worldwide promoter of the Dutch expertise as it relates to water in the Dutch private and public sectors.

Crown Prince Willem Alexander of the Netherlands is a great ambassador for the Dutch water sector. His job is surely made easier by the strong water sector in his homeland.

Drinking water and Delft

Delft

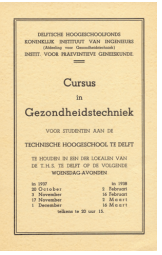
The city of Delft is the water knowledge city of the Netherlands.

Delft University of Technology (TU Delft) and UNESCO-IHE are technical universities with outstanding reputations and both attract national and international students.

Other internationally well-known water institutes in Delft are WL|Delft Hydraulics, GeoDelft and UNICEF-IRC.

TU Delft

In 1937 the "Faculteit Weg- en Waterbouwkunde der Technische Hogeschool te Delft" (or "Faculty Road and Water Engineering of the Technical University of Delft") started with education about the public drinking water service. The future engineers were educated in the fundamentals of the infrastructure for a drinking water service, under the guidance of Mr. Krul, who was the director of the Dutch Governmental Institute for Drinking Water. In 1947, he became the first professor of drinking water in the Netherlands. At that time the domain was considered more like "art" than "science."


DELFTSCHE HOOGESCHOOLFONDS
KONINKLIJK INSTITUUT VAN INGENIEURS
(Afdeeling voor Gezondheidstechniek)
INSTIT. VOOR PRAEVENTIEVE GENEESKUNDE

Cursus
in
Gezondheidstechniek
VOOR STUDENTEN AAN DE
TECHNISCHE HOOGESCHOOL TE DELFT
TE HOUDEN IN EEN DER LOKALEN VAN
DE T.H.S. TE DELFT OP DE VOLGENDE
WOENSDAGAVONDEN
in 1937 in 1938
20 October 2 Februari
2 November 16 Februari
17 November 2 Maart
1 December 16 Maart
telkens te 20 uur 15.

The 1st lecture (1937)

Prof. Krul (1947-1964)

Prof. Huisman (1964-1984)

Over the years our understanding and explanations have improved.

Professor Huisman developed the scientific base for drinking water supply and his lecture notes on artificial recharge, sedimentation, rapid sand filtration, and slow sand filtration became international classics, and are still used today.

Huisman's successor in 1984 was Professor Kop, who introduced the environmental aspects of drinking water supply into the curriculum.

Since 1990, the chair of drinking water education has been Professor van Dijk, who modernized the curriculum and has focused on the development of advanced technology to achieve the goal of high quality drinking water.

Moreover, he has developed a close collaboration between TU Delft and the Dutch water industry, including Kiwa, the research institute of the Dutch water companies.

Inauguration of Prof. van Dijk

Education

TU Delft offers several possibilities to study water-related topics.

Within the BSc program on civil engineering, students are introduced into hydrology and water management.

In the MSc program, students can choose specialized programs in hydrology, water management and sanitary engineering. Within sanitary engineering several courses on drinking water infrastructure are taught, including treatment processes, practical applications and design exercises.

The faculty of Civil Engineering and Geosciences

Field experiments in Luxembourg

Students include Dutch and international BSc-graduates, but also BEng-graduates and "mid-careers," who are already working at water companies and follow a part-time, intensive course.

The courses are given by academics working at the university and at Kiwa and sometimes by special guest lecturers, like the Dutch Crown Prince Willem-Alexander.

Crown Prince Willem-Alexander during a guest lecture at TU Delft

Students in front of a lecture hall

Laboratory course

Excursion to the infiltration in the dunes

Celebrating the completion of design course

Research

The primary focus of the research of TU Delft on drinking water lies on providing high quality drinking water. Challenges for research are:

- optimizing existing infrastructure (through modeling and improved operation)
- developing new technologies (such as membrane filtration, UV-disinfection) to improve water quality and to deal with emerging threats such as Legionella and endocrine disrupting compounds (EDCs)
- developing an integrated approach for the design and operation of the urban water cycle (drinking water, sewerage, wastewater treatment) as a whole, rather than the individual elements.

In March 2006 there were 12 on-going PhD projects on drinking water supply.
The PhD projects are defined in close cooperation with partners from the water sector. All projects are funded by these partners, which ensures that the projects are well-prepared and supported. Experimental research is carried out at drinking water treatment plants and sometimes the results are immediate adopted by the water companies. This provides a highly stimulating environment for the PhD students.

Laboratory research

Pilot plant research

Our researchers regularly organize workshops, congresses and colloquia. The results of the research are published in scientific journals and presented at scientific congresses, and also in Dutch journals.
The research is primarily focused on the Dutch water sector and attuned to the research program of Kiwa, but is carried out in an international framework and in cooperation with foreign universities. The drinking water research group is actively involved in several European research projects. A special project that is being conducted in close collaboration with Kiwa Water Research and UNESCO-IHE is called “Quality for the 21st century.”
In this project attention is given to:

- identifying new emerging substances (pesticides, pharmaceuticals) in the source waters, and the treatment processes to remove these substances
- defining the biological stability of water to prevent quality deterioration (a.o. Legionella) in the distribution system and in home installations
- maintaining drinking water quality in the distribution system

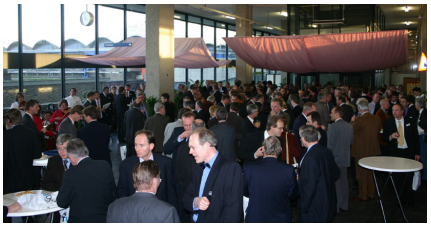
PhD graduation of Jasper Verberk (2005)

Vakantiecursus

Every year TU Delft organizes a symposium for the Dutch water world.

This symposium is called “Vakantiecursus,” which in English would mean something like “Holiday course.” This name originates from the early days in 1948 when Professor Krul thought that it was a waste of money not to use the lecture halls during the holiday period, so he organized a course for the alumni of the university, and engineers, scientists and managers of water companies to keep them updated with the latest developments in the field of drinking water.

Full lecture hall (annually, from 1948)



In the corridors and New Year’s reception

The content of the Vakantiecursus has changed somewhat over the years: from exchanging technical experiences in drinking water, to science, the environment, policy and management.

Over the years it has developed into the leading Dutch congress on drinking water.

Because the Vakantiecursus is scheduled for the second Friday of the new year, it also serves as a New Year’s party for the Dutch water world. This provides an opportunity to review the highs and lows of the year gone by, noting that we will learn from our missteps and build on our progress in the year to come.

Biannual Gijs Oskam Award for best MSc-thesis

Prof. van Dijk during his annual “state of the union”

Every year over 400 water professionals take part in the Vakantiecursus to listen to presentations by national and international experts, such as Don Bursill (CRC WQ&T, Australia), Wolfgang Kuhn (TZW, Germany), Jim Manwaring (AWWARF, USA) and Fred Hauchmann (EPA, USA).

Fast coffee served by students

Learning and laughing combined

Acknowledgement

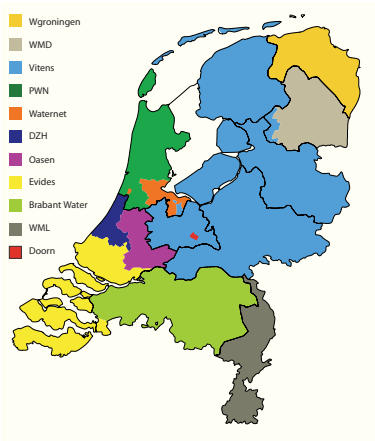
Background

The introduction of the Bachelor/Master structure in 2002 to synchronize the educational structures within all European universities has forced the Faculty of Civil Engineering of TU Delft to modify its curriculum. The Bachelor's basic course is designed to give a broad overview. Since drinking water practices vary greatly, even within western countries, the faculty decided to use the Dutch experiences as an example. Understanding this well-developed and successful framework makes it easier for students to study situations found in other countries and cultures.
Additionally, it was decided to provide the students with the theoretical principles of modern drinking water supply and also show them the designed solutions in actual practice.

Support

The compiling of these course modules was preceded by a long history of involvement of many people, which also parallels the history of the drinking water education program at TU Delft.
The experiences and perspectives of the Dutch drinking water sector have been extensively used for the preparation of this book. VEWIN, Kiwa and the Dutch drinking water companies have generously provided pictures and other illustrative materials. Material from DHV-projects has also been used.

In particular, we would like to thank the following companies for their enthusiastic cooperation and readiness to make photographic illustrations available:
- Waterbedrijf Groningen
- Waterleidingmaatschappij Drenthe
- Vitens
- PWN Waterleidingbedrijf Noord-Holland
- Waternet (Amsterdam Water)
- Duinwaterbedrijf Zuid-Holland
- Oasen
- Evides
- Brabant Water
- Waterleiding Maatschappij Limburg
- VEWIN
- Kiwa
- DHV



The Dutch water companies assisted in information and photos

The authors would like to show their gratitude for this uplifting cooperation and advise their readers that the property rights to these pictures lie with the relevant companies. A special word of thanks is due to Kiwa and in particular Ron van Megen for support with the publishing of this manuscript.

This book was originally published in the Dutch language. The overwhelming response from readers has not only resulted in a second, extended edition, but has also led to the publication of this English language text.
We received valuable comments from the following people:

- M. den Blanken (PWN)
- C. Bruggink (Hydron)
- R. Campen (DHV)
- M. Gast (Waternet)
- P. Hesselink (Kiwa)
- J.P. van der Hoek (Waternet)
- K. Hoogsteen (WMD)
- Th. van den Hoven (Kiwa)
- E. Hulshof (WML)
- P. Jonker (DZH)
- P. Kamp (PWN)
- J. Koelink (WGroningen)
- J. Kop (TU Delft)
- H. de Kraa (Evides)
- H. van Lieverloo (Kiwa)
- R. van Megen (Kiwa)
- P. Mense (Oasen)
- M. Mons (Kiwa)
- W. van Paassen (Brabant Water)
- T. Schmitz (VEWIN)
- R. Schuurmans (Waternet)
- G. Vogelesang (Evides)
- F. van der Willigen (WML)
- J. van Winkelen (Vitens)

Production team

With texts, pictures and illustrations there was still no book. Without Adele Sanders (English translation and editing) and Eefje Ooms (layout and composing), we would never have succeeded in processing all these pieces into a professional product.

For the technical realization of the manuscript, we want to thank all the staff and students who helped with its preparation, in particular Michiel van der Meulen (composing), Bertus van Woerden (illustrations), Simon Frans de Vries (illustrations), Paul Korthagen (layout and software support), and Martijn Klootwijk (material collection).

Authors

Peter de Moel (1954) has been working in the drinking water sector since 1979. Within Kiwa Water Research (1979-1980), he published on water chemistry, on coagulation, and on dewatering of drinking water sludge.

Within DHV (1980-2000), he designed water supply facilities for all drinking water companies in the Netherlands, and for organizations in over 20 countries, worldwide. His patents (membrane filtration) are applied in full scale installations.

Since 2000, he works in his own consulting firm and is a part-time lecturer at TU Delft.

Peter de Moel

Jasper Verberk

Jasper Verberk (1970) started working at TU Delft as a lecturer and researcher in 1996.

In 2005 he finished his PhD research on the application of air in membrane filtration.

Presently, he is assistant professor at TU Delft and has a 1.5 year research assignment at the Cooperative Research Centre for Water Quality and Treatment in Adelaide, Australia.

Hans van Dijk

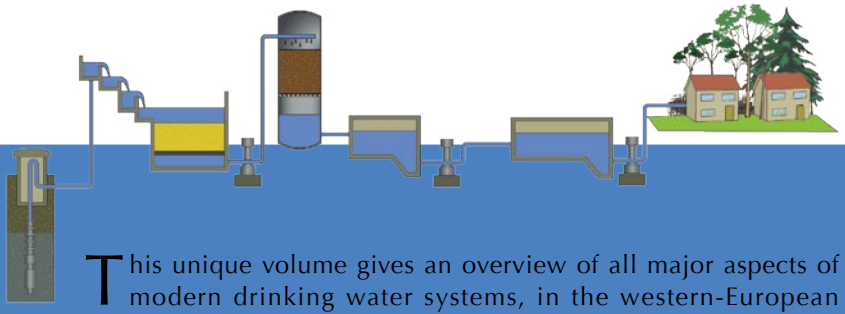
Hans van Dijk (1954) is a water-quality expert with life-long experience in the field of drinking water supply. Since 1990 he has been the lead professor in drinking water supply at TU Delft. In 1991, he was awarded the IWA Maarten Schalenkamp Award for his work on the development of pellet reactors for the softening of drinking water.

Since 2001 Hans van Dijk is also the scientific director for Kiwa Water Research. Presently, Professor van Dijk is chairman of the Department of Water Management at TU Delft, member of the board of the Global Water Research Coalition, chairman of the Dutch Water Tower Foundation and member of the board of Aqua for All.

Register

Drinking Water

Principles and Practices



This unique volume gives an overview of all major aspects of modern drinking water systems, in the western-European context.

It not only covers the theoretical principles, but also the historical background and practical aspects of design and operation, legislation, planning and finance of drinking water supply in its social and economic context.

The principles and practices are illustrated using experiences from The Netherlands. The Dutch drinking water supply is well known for its multiple barrier systems and high technical standards. As a consequence of this, the Dutch readily drink tap water and do not see the need to buy bottled water or in-house filters.

Drinking Water – Principles and Practices offers:

- the best illustrated textbook on water supply, written by internationally recognized experts
- 10 separate modules for tailor-made courses and self-education, complete with questions and answers
- backgrounds on water quality, water consumption, water distribution legislation, finance, design and planning
- drinking water production schemes and processes for groundwater and surface water
- lecture notes from a leading technical university on drinking water supply

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