Microbial risks of recreational waters

Gezondheidsraad **President**
Health Council of the Netherlands

To the Minister of Housing, Spatial Planning and the Environment

Subject	: Presentation of advisory report 'Microbial risks of recreational waters'
Your reference	: DWL/99132424
Our reference	: U 2351/SD/mj/636-J
Enclosure(s)	: 1
Date	: November 27, 2002

Please find enclosed, in response to the letter with the reference stated above, an advisory report about the quality of recreational waters. It has been drafted by a committee formed for that purpose by myself and assessed by the Health Council's Standing Committees on Health and Environment, and on Infectious Diseases and Immunity. In accordance with the request for an advisory report which I received, I have also submitted this advisory report to the Minister of Housing, Spatial Planning and the Environment.

The committee notes that a tightening up of the current standards for faecal contamination is necessary and that the implementation of the system of standards also requires improvement. Furthermore, it has proposed recommended exposure limits for the pathogen which, in the opinion of the committee, constitutes the greatest risk, namely cyanobacteria. I ask you to consider including recommended exposure limits for this pathogen in the Safety and Hygiene in Bathing Establishments and Swimming Pools Act, even if the European Commission does not reach agreement about a directive with suggestions for recommended exposure limits. The Infectious Diseases Act includes enough provisions for taking action with respect to diseases caused by other pathogens.

During the discussion of repressive measures, the committee discussed the extent to which the decision about whether or not to bathe in a particular recreational water is the responsibility of the recreationists themselves. The committee proposes, in the case of less serious diseases, limiting action to the provision of information or a recommendation not to bathe and proposes limiting the use of bans to exceptional circumstances.

P.O Box 16052
NL-2500 BB Den Haag
Telephone +31 (70) 340 75 20/6487
Telefax +31 (70) 340 75 23

Visiting Address
Parnassusplein 5
NL - 2511 VX Den Haag
email: sies.dogger@gr.nl

In conclusion, I wish to draw your attention to the fact that the current standards for recreational water only apply to sites which have been designated as bathing water. However, certain groups of recreationists (such as surfers and divers), which the committee has identified as high-risk groups because of a higher exposure to pathogens, often use waters which are not designated as bathing water. I ask you to consider introducing the standards for bathing water for use with waters in which these types of recreational activity take place frequently.

In part with a view to the Dutch contribution to consultations about the amendment of the European directive for bathing water, you will receive a translation of the advisory report in English in January 2002.

Yours faithfully,

signed
Professor JA Knottnerus

P.O Box 16052
NL-2500 BB Den Haag
Telephone +31 (70) 340 75 20/6487
Telefax +31 (70) 340 75 23

Visiting Address
Parnassusplein 5
NL - 2511 VX Den Haag
email: sies.dogger@gr.nl

Microbial risks of recreational waters

to:

the Minister of Housing, Spatial Planning and the Environment

the Minister of Health, Welfare and Sport

No 2001/25E, The Hague, 27 November 2001

The Health Council of the Netherlands, established in 1902, is an independent scientific advisory body. Its remit is “to advise the government and Parliament on the current level of knowledge with respect to public health issues...” (Section 21, Health Act).

The Health Council receives most requests for advice from the Ministers of Health, Welfare & Sport, Housing, Spatial Planning & the Environment, Social Affairs & Employment, and Agriculture, Nature Preservation & Fisheries. The Council can publish advisory reports on its own initiative. It usually does this in order to ask attention for developments or trends that are thought to be relevant to government policy.

Most Health Council reports are prepared by multidisciplinary committees of Dutch or, sometimes, foreign experts, appointed in a personal capacity. The reports are available to the public.

Preferred citation:
Health Council of the Netherlands. Microbial risks of recreational waters. The Hague: Health Council of the Netherlands, 2001; publication no. 2001/25E.

ISBN: 90-5549-416-X

Contents

Executive Summary

The current standards relating to natural swimming water are based on a European Directive from 1976 and concern the level of faecal contamination. Partly with reference to a revision by the European Union of current standards relating to natural swimming water, the Minister for Housing, Spatial Planning and the Environment has asked the Health Council of the Netherlands to issue an opinion on the risk to bathers of pathogens in natural swimming water and to investigate what control measures can be adopted, apart from imposing a ban on swimming.

Safety chain

The commission that has drawn up the opinion proposes subsuming the management measures relating to natural swimming water within a so-called safety chain (proaction, prevention, preparation, repression and aftercare).

In the proactive phase, it is examined on the basis of what is known as a risk profile whether swimming water is suitable for that purpose. If this is the case, the water is given the designation 'suitable as swimming water', and this can be specified on a map to be drawn up by the provincial authorities. The commission also considers that a management plan must be drawn up at this stage fleshing out the measures in the other four phases in the chain. If sources exist, recommended values are exceeded or if there is an unacceptable risk, preventive action must follow. Preventive action is geared either to eliminating or isolating sources or to measuring concentrations of pathogens. Preparation (preparation for taking repressive measures) covers measurements, inspections, formulation of the criteria on the basis of which decisions are taken and establishing scope for control.

Repressive measures may be geared to sources and to the public (notification, advising, prohibiting). The commission deems a ban necessary only very exceptionally. This is bound up, in its view, with the nature of the effect of the pathogen concerned. In the case of the various pathogens, it indicates what measures are desirable. Aftercare encompasses medical treatment, evaluation of incidents and the question of whether, and under what conditions, the water can retain its function as swimming water. This completes the chain.

With the management measures in the five links of the safety chain, a comprehensive system is formed which is based not only on bans. Designating or not designating water as swimming water on a provincial map, on the basis of a risk profile, and the drafting of a management plan are regarded by the commission as the most important links in this chain.

Pathogens and measures

Water naturally contains innumerable types of micro-organisms, of which a limited number can cause disease in humans. In addition, pathogens also end up in natural swimming water as a result of faecal contamination of human or animal origin. The commission only discusses pathogens which, in its opinion, pose a major risk to swimmers, whether as a result of their incidence or because of the seriousness of the effect. Pathogens originating from faecal contamination are to be found in both fresh and salt water; the other pathogens discussed occur, with the exception of *Pseudomonas aeruginosa*, only in fresh water.

Current (bacteriological) standards for natural swimming water concern the indicators ‘total coliform bacteria’ and ‘thermotolerant bacteria of the coli group’. The selection of these indicators is based on the assumption that there is a definite relationship between the occurrence of these bacteria and that of pathogenic micro-organisms. Since 1976 the relationship between various indicators and the occurrence of disease symptoms has been studied in the various investigations. These investigations show that a causal link exists between exposure to faecal contamination and the occurrence of gastroenteritis. The indicators ‘intestinal enterococci’ and ‘*Escherichia coli’* prove to be most closely connected with such occurrence. The commission derives recommended values from epidemiological research, corresponding to the observation threshold in that study. In the case of fresh water, this value works out at 2400 *Escherichia coli* per litre, while the corresponding value for salt water works out at 300 intestinal enterococci per litre. In view of the natural variation in the salt concentration in different waters, the commission advocates applying both recommended values on inland waterways. Maintaining both limit values signifies a tightening-up of the present standards.

In drawing up the risk profile, existing (statutory) measurements and a list of sources of faecal contamination can be used. The commission considers that the vicinity of overflows or discharges of sewage treatment plants does not go hand-in-hand with the function of ‘swimming water’. It considers measures to, where possible, relocate these sources to be a matter of great urgency.

Within the current standards framework, one sample per location is taken to establish the level of contamination. The commission considers the representativeness and reproducibility of this to be insufficient to be able to make reliable risk assessments. Research on variation in faecal contamination must show what sampling strategy is the optimal one. At the present time, the commission considers a mixed sample from ten locations to be the minimum necessary.

In addition, it recommends tailoring the frequency of measurements to the expected risk. To prevent cases of disease, action must be taken straight after an overrun. Further research is then necessary to trace the sources of faecal contamination and check whether the contamination persists and whether the measures should remain in force.

The commission considers — in view of the lesser seriousness of the effect of faecal contamination (the occurrence of gastroenteritis) — that, when the recommended values are exceeded, restraint is desirable concerning a ban. It considers discouraging swimming to be sufficient in such cases. As long as the current EU Directive is in force, the issue of a ban remains necessary when the standards in force are exceeded.

Cyanobacteria — a second group of pathogens, wrongly designated as blue algae — are generally occurring in the Netherlands. Various types produce highly poisonous toxins. The toxin microcystine poses the greatest danger by virtue of its incidence and effect (liver damage). The commission adopts the recommended value of 20 micrograms per litre as proposed by the World Health Organization (WHO). This value has been derived from animal research. In view of the nature of the effect of microcystine, the commission considers a ban to be justified if the recommended value is exceeded. Such an overrun may be expected in a large number of bodies of water. If there is a scum (surface bloom) of a species that produces microcystine, this will almost always be the case. In addition, the presence of high concentrations of cyanobacteria (as in scums) often leads to skin irritation. The commission considers that cyanobacteria merit at least as much attention as faecal contamination. It deems the formulation of a risk profile and monitoring of both cyanobacteria and toxin concentrations to be of great importance. Preventive measures are scarcely possible for these bacteria; only the reduction of eutrophication can provide any relief.

The larvae of the flatworm *Trichobilharzia ocellata* cause swimmer's itch (cercarial dermatitis). This flatworm is a parasite of birds and primarily uses water snails as an intermediate host. The commission has drawn up a decision-making schedule for management measures to be taken. These measures are chiefly geared to establishing the presence of (infected) snails and their removal.

Pseudomonas aeruginosa, a bacterium which occurs naturally in water, causes inflammation of the skin in the outer auditory canal (otitis externa). Particularly if the temperature of the water is more than 18°C, high concentrations of this bacterium may occur. Management measures are scarcely possible. Should a lot of complaints arise after swimming in a particular body of water, and the temperature is more than 18°C, discouraging swimming there should be considered.

Some other pathogens (Leptospira, *Clostridium botulinum*, *Naegleri fowleri*, *Acanthamoebae* and *Balamuthia mandrillaris*) may cause diseases that are very serious and even potentially fatal. Leptospirosis and botulism are covered by the Infectious Diseases Act and are notifiable. A serious form of leptospirosis is Weil's syndrome. About forty cases of severe leptospirosis occur each year in the Netherlands, a large proportion of which have been contracted abroad. Leptospirosis is transmitted via the urine of, in particular, rats. Management measures are primarily geared to decimating the rat population. Should cases of leptospirosis be attributable to a particular body of water, the site in question should be closed.

Clostridium botulinum is the agent responsible for causing botulism. The toxin produced by certain strains of this bacterium is one of the most potent in existence. The bacterium produces toxins in dead fish and ducks. Since, in the Netherlands, it is stipulated in the Dry Rendering Act that dead animals must be disposed of immediately, botulism does not occur in swimmers in this country.

Naegleri fowleri, *Acanthamoebae* and *Balamuthia mandrillaris* may cause severe inflammations of the brain. These diseases have never been detected in the Netherlands. The pathogens are mainly to be found in warm fresh water and have, including in the Netherlands, been detected in the cooling water of power stations. A ban on swimming in such water is, according to the commission, sufficient to prevent cases of disease.

High-risk groups

People belong to a high-risk group if their exposure or sensitivity to pathogens present in natural swimming water is higher than for the average person. For people who, owing to increased sensitivity, belong to a high-risk group, it is in the commission's view primarily a matter for the attending physician to provide information on this and on whether or not swimming is advisable.

Chapter 1

Introduction

1.1 The request for an advisory report

The Minister of Housing, Spatial Planning and the Environment has, through the Minister of Health, Welfare and Sport, asked the Health Council to draw up an advisory report about the standards for the quality of surface water which is used as bathing water. The reason for this request was the proposed revision of the European directive on bathing water. The request was also motivated by research results indicating that the current system of standards does not provide bathers with full protection against health problems. A committee appointed for that purpose by the Health Council drafted the present report in response to the request for an advisory report (annex A). The names of the members of the Committee are listed in annex B.

In the request for an advisory report, the Minister asks four questions about the standards for, and the risks posed by, recreational waters:

- What is the opinion of the Health Council about the system of standards and microbiological standards currently in place (pursuant to the Swimming Pools (Hygiene & Safety) Act) for the prevention of risks of infection as a result of bathing in surface water?
- Which pathogens play a role in terms of the risk of bathing in surface water?
- Are specific recommendations required for vulnerable groups, such as people with an impaired immune system, with respect to bathing or recreation in surface waters?

- Would it be desirable to check other risks, for example of a chemical nature, in addition to microbiological parameters in order to protect bathers' health? If so, which parameters should be considered in this respect?

Two questions relate to control measures and informing the public about them:

- Which criteria could be followed, when introducing a ban on bathing, alongside or instead of existing criteria (statutory standards)? Would you also consider it to be sensible to develop criteria which could be used as a basis for advising against bathing or issuing a recommendation not to bathe?
- How, in addition to the arrangements already in place, would you inform the public about the risks of bathing in surface water?

In conclusion, the Minister asks what the primary focus should be of research into the risks of infection as a result of bathing.

1.2 Preview and structure of the advisory report

Natural water is a dynamic ecosystem, consisting of numerous species of micro-organisms, plants and animals. A limited proportion of these organisms can cause diseases in humans. In addition, pathogens also enter recreational waters as a result of faecal contamination of human or animal origin. Bathing in recreational waters therefore always involves risk. The Committee confines its discussion to pathogens which, in its opinion, pose a major risk to bathers, whether as a result of the levels at which they occur or because of the severity of the effects they produce.

Effect, exposure and recommended exposure limits

The advisory report has, as far as possible, adopted a classification for pathogens ranging from common pathogens which result in less severe symptoms to rare pathogens which can cause severe illness. In chapter 2, the Committee looks at the recommended exposure limits and indicators for faecal contamination of bathing water. In chapter 3, it discusses the exposure limit for cyanobacteria (blue-green algae; the agent of gastro-enteritis and liver damage). In chapter 4, it discusses schistosomes (which cause swimmer's itch) and *Pseudomonas aeruginosa* (the agent of inflammation of the external auditory canal). It is not possible to set recommended exposure limits for these pathogens: the available data for *Pseudomonas aeruginosa* is inadequate for this purpose and the Committee advocates a preventive approach for schistosomes. In chapter 5, the Committee looks at pathogens for which no recommended exposure limits are necessary because the hazard posed by their presence must always result in action being taken. Where possible, in the individual chapters, the Committee will state the results of risk assessments for the various pathogens in recreational waters. With the exception of *Pseudomonas aeruginosa* and the pathogens present in faecal contamination, the pathogens referred to above are found only in fresh water.

Chain approach

In chapter 6, the Committee discusses a 'safety chain' which can be used as a framework for control measures. This model also deals with communications with the public about risks. By opting for this approach, the Committee departs from the prevailing standards framework and places the emphasis on preventive control measures.

In chapter 7, the Committee discusses which control measures are necessary and also states what significance it believes should be given to the recommended exposure limits proposed in the previous chapters.

In the final chapter, the Committee replies to the Minister's questions.

Chapter **2**

Faecal contamination of recreational waters

2.1 Current standards and international background

The current bacteriological standards for recreational waters can be found in a European Union directive dating from 1976. They use the indicators ‘total coliforms’ and ‘thermotolerant coliforms’. In 2002, the directive will be amended. It is expected that the indicators referred to will be replaced by: ‘*Escherichia coli*‘ and ‘intestinal enterococci’.

It is unclear what scientific data was used as a basis for the 1976 directive. As far as the Committee is aware, there are no documents stating how the standards were derived.

In 1986, the American *Environmental Protection Agency* (EPA) used epidemiological research as a basis for drawing up recommended exposure limits for ‘*Escherichia coli* ‘ and ‘intestinal enterococci’ in recreational water. The World Health Organisation (WHO) recently proposed an exposure limit for ‘intestinal enterococci*’ in recreational water based on the epidemiological research available at the time. The EU intends to adopt this WHO limit if this is economically feasible.

* The difference between ‘Intestinal enterococci’ and ‘feacal streptococci’ is minimal. The committee prefer the use of ‘intestinal enterococci’ instead of the older expression ‘feacal spreptococci’

2.2 General information

There are various sources for the faecal contamination of recreational water. Human excrement enters surface water via the effluent of wastewater treatment plants or as a result of ‘overflows’ from sewage systems (sewage water enters surface water after severe rainfall). Bathers themselves are another source. The main animal sources are: run-off of manure from agricultural areas and the faeces of waterfowl.

Faecal contamination consists largely of harmless intestinal bacteria. In addition, it contains organisms which cause disease (pathogens) and which come from the intestines: viruses, bacteria and protozoa (single-cell organisms). Examples of pathogens are: various *E. coli* serotypes, *Cryptosporidium parvum, Giarda lamblia*, ‘Norwalk-like’ viruses, *Campylobacter*, salmonella bacteria, enteroviruses, and the hepatitis A and E viruses. Since most pathogens are host-specific, pathogens of human origin are more likely to result in disease in humans than pathogens of animal origin. Most illness resulting from exposure to faeces in bathing water involves gastrointestinal disorders (gastro-enteritis). There can also be problems with the skin, eyes and airways, as well as inflammation of the outer auditory canal.

The main agents in bathing water which can result in gastro-enteritis are probably the parasite *Cryptosporidium parvum,* ‘Norwalk-like’ viruses and *Campylobacter*. These pathogens enter surface waters with human faeces. The run-off of manure is also a route for *Cryptosporidium.* Both ‘Norwalk-like’ viruses and the oocysts of *Cryptosporidium* can survive for some months in water. Small numbers of these pathogens are enough to cause gastro-enteritis. Campylobacter dies off quite quickly in surface water. Partly because the exact role played by these pathogens in levels of disease resulting from bathing water is not known and because the pathogens referred to here only cause part of the disease burden, the Committee bases the recommended exposure limits on indicators for faecal contamination.

Generally speaking, the indicator used is the concentration of bacteria of a specific species or group. A good indicator will be specific for faecal contamination, will occur in faeces and in water in higher numbers than the pathogens, will behave in the same way as the pathogens in water (transport, survival) and will be easy to detect. The indicator concept is already more than one hundred years old and is in widespread use for determining the safety of bathing and drinking water. The methods have been refined during the course of those hundred years. For example, it has emerged that ‘total coliforms’ is not specific enough for faecal contamination because some representatives can also multiply in the environment. In order to make the indicator more specific, the cultivation temperature was raised: thermotolerant coliforms. The current standards for recreational water apply to the latter bacteria. At present, the EU is considering adopting the more specific parameter *'E. coli'*, possibly in combination with 'intestinal enterococci' (as was done recently for drinking water in the Water Supply Decree).

2.3 The relation between faecal contamination and illness

A range of studies have looked at the relationship between various indicators and the incidence of disease. In preparation for the recommended exposure limits to be drafted by the WHO, these studies have been evaluated (Prü98). Most studies used the incidence of gastro-enteritis as a clinical criterion. In some studies, other effects are discussed, examples being disorders of the airways, inflammations of the eye and ear, and skin disorders. The review looked at 22 of the 37 studies available. Twenty of the studies involved observational research (18 prospective and 2 retrospective studies). Two studies had an experimental design.

The 22 studies show that the indicator 'intestinal enterococci' (faecal streptococci) in salt water is most closely correlated to the incidence of gastro-enteritis. For fresh water, this is the case for the indicators 'intestinal enterococci' and '*E. coli* '. The latter is not suitable for salt water because *E. coli* only survives in salt water for a short time. Prüss concludes that the causal link between indicators and gastro-enteritis has been adequately demonstrated (seven of the nine Bradford Hill criteria are met). The two randomised trials, which provide the most convincing proofs, are discussed separately here.

A study conducted for salt water assigned 1,306 adult people in Britain to a group which went swimming or bathing and a group which went to the beach but did not go into the sea (Kay94). Concentrations of various bacteria were determined in the sea at different depths and distances: total and thermotolerant coliforms, *Pseudomonas aeruginosa*, intestinal enterococci and total staphylococci. Of the correlations between the incidence of gastro-enteritis and bacteria concentration, the correlation with intestinal enterococci was the highest. After assigning the bathers to groups on the basis of the level of exposure to intestinal enterococci, the lowest level of exposure resulting in a statistically significant increase in the incidence of gastro-enteritis was between 400 and 600 intestinal enterococci per litre. The researchers calculated a threshold value on the basis of the dose-effect relationship in which there was just no significant increase in gastro-enteritis. This threshold value was 320 intestinal enterococci per litre.

Van Asperen and colleagues conducted a randomised study in the Netherlands of the incidence of gastro-enteritis in 827 triathletes who swam in fresh water and 773 triathletes who did not swim (Asp98). The control group of non-swimmers consisted of *run-bike-runners*. The indicators were 'intestinal enterococci', 'thermotolerant coliforms' and '*E. coli*'. The last two indicators correlated with the incidence of gastro-enteritis. The use of '*E. coli'* as an indicator is preferable to 'thermotolerant bacteria' because *E. coli* is primarily of human origin. The researchers found a threshold value for *E. coli* of 2380 per litre.

There are also difficulties with the epidemiological studies with an experimental design discussed here (Mug00). The Committee does not believe that the discussion in this respect has arrived at a clear conclusion yet. It does not think that it is clear to what extent the study design results in an overestimate or an underestimate of the exposure limit. One of the uncertainties in the studies referred to here relates to exposure. In the triathlete study, there was a factor ten variation in the exposure levels for the indicators measured in the immediate vicinity of individual swimmers. In different conditions, for example if sediment is stirred up, variation may be even greater, for example because accumulations of pathogens can reach high levels in sediment. Sediment can be stirred up in, for example, tidal areas or when people bathe in shallow water.

The Committee concludes that there is a causal relationship between exposure to faecal contamination in recreational water and the incidence of gastro-enteritis. The two trials discussed are, in the opinion of the Committee, and despite a number of shortcomings which are inherent to studies of this kind, satisfactory as a basis for the derivation of recommended exposure limits.

2.4 Health-based recommended exposure limits

The request for advice states a maximum permissible risk (MPR) for recreational water of one infection per 10 000 individuals per year. The Committee has three concerns here. First of all, this value has probably been taken over from the standards for drinking water, which apply to individual pathogens. For bathing water, the Committee prefers — as stated above — standards for indicators of faecal contamination to indicators of individual pathogens. In addition to the objections stated above, measuring individual concentrations of pathogens in recreational water is considerably more expensive than measuring a number of indicators.

Secondly, the Committee would wish to point out that the use of the results of epidemiological research for the derivation of recommended exposure limits means that those recommended exposure limits relate to symptoms of disease. However, the standard for drinking water referred to here talks about preventing 'infection'. Infection often fails to result in clinical symptoms of disease. Equating infection with symptoms also runs up against the difficulty that the indicators to be used relate to a group of pathogens, some of which are unknown, while it is unclear which pathogens account for which symptoms.

Finally, depending on the pathogen and the response of the host, any possible symptoms vary from mild to very severe. In the epidemiological studies discussed here, a very broad definition of gastro-enteritis has been used in which, for example, one instance of diarrhoea is considered to qualify as gastro-enteritis.

The Committee believes that it is acting in the spirit of the basic principles of the environment policy by selecting recommended exposure limits which correspond to the threshold values established by epidemiological research, namely: the level at which no increase in the background incidence of gastro-enteritis has been observed. It is possible that, in view of the inevitably limited accuracy of these studies, the recommended exposure limit may be higher than an MPR value. However, the Committee takes into consideration the fact that the epidemiological studies use very broad definitions of gastro-enteritis. It also takes this into account in its proposed measures in chapter 7.

The Committee proposes rounding off the threshold values determined in the trials (Asp98, Kay94) and adopting them as the recommended exposure limits. This results in the following values: for fresh water, 2400 *Escherichia coli* per litre, and, for salt water, 300 streptococci per litre. In view of the salt concentration gradient there, the Committee advocates applying both of these recommended exposure limits on inland waterways.

The proposed recommended exposure limit for salt water corresponds to the EPA limit, but it is slightly lower than the WHO limit (table 1).

Like the Committee, the WHO's approach is based on Kay's study, but the risk limit it has adopted is the average for the group with the lowest exposure level that results in a significant increase in the incidence of gastro-enteritis. In 1986, the EPA drew up recommended exposure limits for salt and fresh water fixed on the basis of the results of epidemiological research conducted in 1983 and 1984. The risk limit it adopted was

Table 1 Recommended exposure limits for indicators of faecal contamination.

	fresh water	*salt water*
this advisory report	2400 *E. coli*/l and 300 intestinal enterococci/ l	300 intestinal enterococci/ l
WHO		500 intestinal enterococci/ l

an increase of 2% in the background incidence of gastro-enteritis. The EPA recently evaluated (EPA00) the recommended exposure limit it drew up in 1986 and concluded that the research conducted since 1986 contained no grounds for revising that limit.

The recommended exposure limits proposed by the Committee are stricter than the current standards for recreational water. The Committee does not believe that the current standards provide adequate protection. This emerged, for example, from the study with triathletes, in which the concentration of 'thermotolerant bacteria' varied from 6 to 6 500 per litre (an average of 790 per litre), levels which are still a long way below the current EU standard of 20 000 per litre.

Other considerations also justify a stricter recommended exposure limit and require caution. In Kay's study, the dose-effect curve was very steep (Kay94). In that research, a quarter of the bathers (above the background incidence of one in ten in the control group) had gastro-enteritis at values of 1 000 intestinal enterococci per litre. Furthermore, the study was limited to healthy volunteers aged over 18. There are, however, risk groups which differ from healthy volunteers in the level of exposure, sensitivity to infection and severity of symptoms. The Committee will discuss this issue in chapter 8.

Faecal contamination can also cause other disorders in addition to gastro-enteritis. Fleisher and colleagues looked at the incidence of respiratory complaints ("acute febrile respiratory illness") and eye, ear and skin disorders in this study conducted by Kay and colleagues (Fle96). The incidence of respiratory complaints and inflammation of the outer auditory canal correlated with the concentrations of bacteria measured: intestinal enterococci and thermotolerant coliforms respectively. The threshold value found for inflammation of the outer auditory canal was 1 000 thermotolerant coliforms per litre. For respiratory complaints, the threshold was 600 intestinal enterococci per litre. This latter value is slightly higher than the stated threshold for gastro-enteritis. The symptoms in bathers with respiratory complaints persisted for six days and more than 20 per cent requested medical assistance. The symptoms of inflammation of the outer auditory canal persisted for eight days; 20 per cent consulted a GP. The correlation found between the two indicators and symptoms which were measured (other than gastro-enteritis) is not, however, adequate to prove a causal link.

A major source of uncertainty about the level to which the proposed recommended exposure limits provide protection is found in the pathogen-indicator ratio and the virulence (the potential to induce illness) of the pathogens. A range of factors have an effect on this ratio. If the faecal contamination comes from a large proportion of the population (and if there is not, by chance, an epidemic in progress), the ratio will be the same in a large area. Since faeces can also come from small subpopulations (for example of bathers) or from animals, the ratio will not always be fixed. This ratio and the virulence of the pathogens will be very different if agricultural animals are the main source. Virulence need not necessarily be less when this is the case, as is shown by the contamination of a lake with *E. coli O 157* from cows (Ack97). In older people, infection with these bacteria can result in bloody diarrhoea and it can sometimes result in kidney failure in children.

In the Netherlands, it is reasonable to expect a certain homogeneity in the type of contamination. The composition of the surface water is largely determined by Rhine and Maas river water, which contains a mixture of human and animal faeces. This means that the indicator to pathogen ratio will be comparable in most locations. That this is indeed the case is shown by the results of measurements at intake points for drinking water, which are often located in the major rivers or their tributaries.

2.5 Non-compliance with recommended exposure limits, risk assessment

The Committee has compared concentrations of indicators of faecal contamination from more than 700 locations (data source: RIZA (Dutch Institute for Inland Water Management and Wastewater Treatment)) for the period 1996 to 2001 to the recommended exposure limits it drew up (see table 2).Not enough measurements of the indicator *'E. coli'* are available for determining non-compliance with recommended exposure limits. A non-compliance percentage can be established for thermotolerant coliforms. Most studies show that the concentrations of *E. coli* are in a range which corresponds to the concentrations of thermotolerant coliforms. The Committee therefore used the recommended exposure limit for *E. coli* for the purposes of the above comparison. On the basis of average concentrations, 10 per cent of the sites failed to meet the recommended exposure limits for both fresh and salt water.

Concentrations in the Rhine and Maas rivers and effluent from sewage treatment plants

As stated above, the composition of the surface water is largely determined by water from the Rhine and Maas. From 1996 to 2001, the concentration of intestinal enterococci in the Rhine was, on average, 6 900 bacteria per litre. The average concentration in the Maas river was 31 000 bacteria per litre. Effluents from sewage

Table 2 Number of sites at which the recommended exposure limit was exceeded in the period 1996 to 2001 (as a percentage), based on the average or geometric mean concentrations.

	number of sites	calculated using the average	calculated using the geometric mean
salt: intestinal enterococci	99	11	0
fresh: thermotolerant coliforms	638	10	2

treatment plants and overflows also have an effect on the microbial quality of recreational water in various sites. In effluent from two sewage treatment plants, average concentrations of thermotolerant coliforms were found of 1 100 000 and 690 000 bacteria per litre.

Risk assessment

In order to calculate the contribution to the incidence of gastro-enteritis of exposure to recreational water, information is required relating to: the frequency and the degree to which people are exposed, as a result of bathing, to faecal contamination, and the background incidence of gastro-enteritis in the general population. In view of the availability and uncertainty of the data, the calculation below should be seen as an indication only.

No precise data is available about bathing frequency in the Netherlands. The Committee estimates that the total annual frequency for both fresh and salt water is 1 to 10 million in the Netherlands. The number of occasions on which people bathe will not be distributed over the population along normal lines.

The Committee derived recommended exposure limits for fresh and salt water from the research discussed above (in 2.3). These studies also include data about the risk of gastro-enteritis for bathers exposed to concentrations above the limit and for the control group. In one study (Asp98), 9% of those who bathed in water with concentrations above the limit value fell ill, as opposed to 3% in the control group. In the other study, 25% of those who had bathed in water with concentrations above the limit value had symptoms. This figure was 10% for the non-bathers. On the basis of the data stated above about exceeding the recommended exposure limit, estimates can be drawn up of the risk of gastro-enteritis. Furthermore, the calculation below uses the percentage of sites at which the average exceeds the limit value. Because an average value has been used, it can be assumed that bathers are exposed to concentrations which are either above or below the recommended exposure limit. The possibility of this happening has been set at 50% in this calculation.

The number of people who contract gastro-enteritis as a result of bathing can now be calculated as follows:

frequency of bathing x percentage of sites above the limit value x 50% (exposure above the limit value) x (difference in percentage of gastro-enteritis between exposed subjects and control group). The figure calculated in this way, divided by the total number of cases of gastro-enteritis (percentage control group x 16 million inhabitants), results in the proportion of gastro-enteritis caused by bathing water in total gastro-enteritis numbers.

Entering the following figures:

- frequency of exposure: 1 or 10 million a year
- non-compliance percentage: 10 % (for both fresh and salt water)
- percentage gastro-enteritis (difference between exposed subjects and control group):
- fresh water: 8.9 - 3.3% = 5.6%
- salt water: 25.6 - 9.7 = 15.9%
- total numbers gastro-enteritis cases: (percentage gastro-enteritis x 16 million inhabitants)

results, for both fresh and salt water, in a share of gastro-enteritis resulting from bathing water of approximately 0.5% for 1 million exposures and 5% for 10 million exposures a year. On the basis of this calculation, which the Committee considers to be indicative only, the contribution of bathing in recreational water to the incidence of gastro-enteritis in the general population can be described as quite minor.

Chapter 3

Cyanobacteria in recreational water

3.1 General

Cyanobacteria occur everywhere in the world, in fresh and salt water and from the tropics to the polar regions. These bacteria probably made life on earth possible for other organisms because they were the first organisms able to produce oxygen by photosynthesis. Fossil cyanobacteria have been found which are 3.5 billion years old.

Many strains of these bacteria — erroneously referred to as blue-green algae — produce highly poisonous toxins. There were reports in Australia two centuries ago of cattle dying after drinking water containing cyanobacteria (Fra78). Elsewhere, mass deaths of horses, sheep, cows, ducks and other animals have been linked to the presence of these bacteria in water. In many areas, the use of drinking water contaminated with cyanobacteria has been linked to, for example, gastro-enteritis, liver damage and, in a few cases, human deaths. Health problems in recreationists have also been blamed on the presence of cyanobacteria.

Laboratory research shows that different strains of cyanobacteria produce different types of toxin. For example, there are toxins which specifically target the liver or the nervous system. Others are poisonous for all types of cell. In addition to toxins, many cyanobacteria also produce lipopolysaccharides (LPS). These substances can cause complaints such as skin irritation, allergic responses and gastro-enteritis.

Cyanobacteria are found in virtually all larger bodies of water in the Netherlands, but not in waters with strong flows such as rivers. In the Netherlands, the major strains are those from the genera *Microcystis*, *Anabaena*, *Aphanizomenon* and *Planktothrix*.

Almost all populations increase during the course of the summer, peaking at the end of the summer season (latter half of September). Sometimes, a population of *Anabaena* develops in the spring. *Planktothrix* is the only type known to be active in the winter; all others are dormant in sediment during the winter. *Aphanizomenon, Anabaena and Microcystis* are found in slightly deeper waters (more than 3 metres deep), *Planktothrix* is found in shallower waters (depths of less than 4 metres). *Planktothrix* is particularly prevalent in nutrient-rich waters.

Microcystis, *Anabaena* and *Aphanizomenon* can, in sufficiently large concentrations, form surface blooms which look like blue-green oil paint. These surface blooms can, when there is not a lot of wind, be stable and drift together on a lee shore. Dense populations can result in which high levels of toxins can accumulate. When the wind direction changes, surface blooms can disappear within a day, spreading across and being suspended in the surface water. As was explained above, bathers can be exposed to excessive concentrations of toxins in surface blooms of this kind, both as a result of swallowing water and through contact with the skin or eyes. In this chapter, the Committee examines what constitutes a tolerable concentration of cyanobacteria when these organisms are freely suspended in water, rather than forming a surface bloom. In addition, the Committee presents an overview of the risks for recreationists on the basis of measurements in Dutch inland waters.

At present, there is no official standard for cyanobacteria in recreational water.

3.2 Epidemiological research

Since epidemiological research in this area is usually designed on retrospective lines, there is no data about exposure, for example. However, when data relating to the poisoning of animals, epidemiological data for humans and the results of laboratory research into the toxicity and action of cyanobacteria are looked at together, there is convincing evidence that toxins from cyanobacteria constitute a threat to public health.

There have been reports of a number of incidents outside the Netherlands in which health problems such as gastro-enteritis or liver damage are clearly linked to the presence of cyanobacteria in *drinking water* (see, for an overview, Duy00). Most of the incidents involve reservoirs or drinking water basins from which drinking water is taken and in which there is a growing population of cyanobacteria. Health problems result after cyanobacteria die off in large quantities. This dying-off process takes place either naturally, at the end of a period of growth, or as a result of the introduction of copper sulphate in order to prevent problems with cyanobacteria in the basins. Generally speaking, toxins are released when the bacteria die. It has been shown that the usual techniques for water treatment do not eliminate the toxins.

In the study referred to here, the effect of cyanobacteria was demonstrated indirectly. Two incidents in which dialysis patients were given liquids which proved later to have contained cyanobacterial toxins constitute direct proof of the effect in humans (Hin75, Joc98).

There are no incidents in the Netherlands attributable to drinking water containing cyanotoxins.

Problems such as gastro-enteritis are primarily caused by recreationists swallowing cyanobacteria. By contrast with the incidents referred to here, which result from exposure to dissolved toxins, ingestion of cyanobacteria is the major factor in the recreational context. Problems can also result from exposure through the skin or lungs. Bacterial pigments can trigger severe allergic responses (Coh53). There would appear to be similarities to air-borne allergens. A study of people with respiratory allergies showed that they were also allergic to contact with cyanobacteria (Mit79).

In Great Britain, twenty soldiers contracted symptoms such as vomiting, diarrhoea and mouth sores as a result of canoeing in water with high levels of *Microcystis aeruginosa*. Two of them were admitted with severe pneumonia (Tur90). Bathers in Canada contracted acute gastro-enteritis after bathing in water containing *Microcystis* and *Anabaena* species. Large quantities of these cyanobacteria were found in patient stools (Dil60). Bathers and water skiers in Pennsylvania (USA) ran up acute gastro-enteritis, eye and skin irritation and hay fever-like symptoms, presumably caused by *Anabaena* and *Aphanizomenon* species (Car85).

An epidemiological study indicated that bathers presented symptoms (eye, ear and skin irritation, vomiting, diarrhoea, flu-like symptoms, fever and mouth sores) at levels of no more than 5 000 organisms per litre (Pil97). The water was found to contain *Microcystis*, *Anabaena*, *Aphanizomenon* and *Nodularia* species. However, the researchers do not exclude the possibility that other pathogens, for example of faecal origin, may have caused the observed symptoms. The increase in the incidence of symptoms only occurred seven days after exposure. This indicates that allergens were not involved. It was shown that the symptoms were not related to the concentration of hepatotoxins found and no neurotoxins were shown to be present.

There is one known case of liver damage after bathing in recreational water in the Netherlands. The Committee would like to point out that there are no systems in place for registering these complaints.

3.3 Toxins

Cyanobacteria produce toxins which vary widely in terms of action and structure. It is only in the last 20 years that suitable analysis methods have been developed, research conducted into the toxicity of these compounds and concentrations of these substances measured in water. A striking feature is their high toxicity for mammals and their relatively low toxicity for aquatic animals. In the survey below, the Committee focuses particularly on the main toxins and toxin-producing species. In the Netherlands, the hepatotoxins, and particularly microcystins, constitute the main risk (liver damage) for bathers. In 3.4, the Committee derives recommended exposure limits for microcystin. For a more detailed discussion of both the toxicology and the ecology of cyanobacteria, the reader is referred to the WHO publication ‘Toxic cyanobacteria in water’ (WHO00) and an overview article (Duy00).

Hepatotoxins

Cyanobacteria produce two types of hepatotoxins: cytotoxic alkaloids and cyclic peptides.

Cytotoxic alkaloids are particularly important in tropical countries. The main producer of cytotoxic alkaloids is *Cylindrospermopsis*. In Australia, the toxin caused severe hepatoenteritis (see 3.2). *Cylindrospermopsis* has been found more and more frequently in Europe in recent years (in Lake Balaton for example). However, toxicity in Europe is low. In the summer of 2000, this organism was found in the Netherlands for the first time. It is unclear whether, and to what extent, it will spread further in the Netherlands.

Cyclic peptides consist of rings of five or seven amino acids, and their main representatives are the microcystins and nodularin. The Committee will not discuss nodularins in any further detail here since, in northern Europe, they are only produced by a brackish water species in the Baltic Sea and are hardly found at all in the Netherlands.

Microcystins, on the other hand, are produced by numerous species which are common in Dutch lakes. The molecule consists of seven peptides, three of which are the same in all microcystins. The presence or absence of methyl groups in a long amino acid linked to the ring allows for a large number of different microcystins. They differ from each other in terms of toxicity. The most toxic is microcystin-LR. Often, total concentrations of the various microcystins are considered to represent microcystin-LR. This means that toxicity is frequently overestimated. It should be pointed out that approximately half of all the types which have been tested are roughly half as toxic as microcystin-LR.

The hepatotoxic action of microcystins is based on the strong bond which it forms with an important enzyme in the liver, protein phosphatase. A very low concentration of microcystin (LD50: 50 micrograms per kilogram body weight, administered through the intraperitoneal route) kills mice as a result of haemorrhagic shock resulting from acute damage to the liver. Death after oral administration in mice follows at a level of 5 milligrams per kilogram body weight. Epidemiological research has established a relation between the presence of microcystins in badly treated drinking water and acute liver damage, as well as an increased risk of liver cancer (Yu89; Yu95). There is no experimental proof that microcystins can cause cancer. It has been shown that these substances are very strong tumour promoters (Fal91; Nis92).

Studies of the teratogenity of microcystins have yielded slightly conflicting results. For example, Kirpenko found, after the administration of an extract of *Microcystis aeruginosa* to pregnant rats, increased mortality rates at doses of only 0.0005 micrograms per kg of body weight a day (Kir81). The result of this study is difficult to interpret since the composition of the toxins in the extract is not known. Falconer and colleagues found brain malformations in the offspring of mice which were given extracts of *Microcystis* during pregnancy (Fal88). However, other researchers failed to find any foetal mortality after the administration to pregnant mice of microcystin-LR using a stomach tube, even at doses of 2 milligrams (Faw94). In this study, in which a large number of teratogenic effects were studied, the NOAEL was 600 micrograms per kilogram body weight a day.

In recreationists, microcystins can cause complaints such as headaches, gastro-enteritis, eye, ear and skin irritation, lip sores and severe pneumonia. High microcystin levels are mainly found in species which form surface blooms such as *Microcystis* and *Anabaena*. In surface blooms, there is considerable accumulation of organisms and therefore a high concentration of toxins. Species such as *Planktothrix*, which do not form surface blooms, are also major producers of these toxins.

Microcystins are very resistant compounds which can cope with temperatures up to 300°C for some time and which are also very resistant to proteolysis (the breakdown of proteins). They are also resistant to sunlight, except when cyanobacteria pigments are also present. Certain bacteria can break down the toxins. Depending on the particular conditions, this process of breakdown can take a few days or months.

Neurotoxic alkaloids

This group causes rapid death in mice as a result of respiratory disorders (LD50 after inhalation of 250 micrograms per kilogram body weight, oral LD50 >5 000 micrograms per kilogram body weight). Major compounds in this group are the anatoxins (anatoxin-a, homoanatoxin-a, anatoxin-a(S)) and saxitoxin. Saxitoxins are particularly well-known because of cases of severe poisoning after eating shellfish, where these substances — which come from certain species of phytoplankton — accumulate in high concentrations. However, saxitoxins are also produced by strains of *Aphanizomenon* and *Anabaena*. Both types of cyanobacteria can form surface blooms and they are therefore a major potential hazard for bathers. The main producers of anatoxins are the cyanobacteria *Aphanizomenon* and *Anabaena.* Anatoxins are probably responsible for the cattle deaths referred to above (in 3.1). A survey of 83 recreational waters in the Netherlands conducted in 1998, found no trace of anatoxin (Aqu00).

3.3.1 *Lipopolysaccharides*

Lipopolysaccharides (LPS) are found in the cell walls of Gram-negative bacteria (which also include cyanobacteria). In humans, LPS can cause gastro-enteritis, eye irritation and allergic responses (asthmatic and hay fever-like symptoms) (Fal94). LPS are omnipresent, for example in house dust. It cannot be excluded that some of the symptoms caused by exposure to bathing water can be blamed on certain types of LPS. Skin irritation in bathers would appear to be caused primarily by LPS.

3.4 Derivation of the recommended exposure limit

It was shown in 3.3 that microcystins are in all probability the main toxins in the Netherlands. The WHO has drawn up a recommended exposure limit for microcystins in drinking water in the form of a *Tolerable Daily Intake* (TDI). It uses this as a basis for a recommended exposure limit for recreational water, assuming that recreationists ingest a certain amount of water.

This TDI for drinking water was derived from data produced by studies of the subchronic toxicity of microcystin in laboratory animals. Mice were given microcystin orally for a period of 13 weeks (Faw99). The NOAEL for the incidence of histopathological and enzymatic changes in the liver was 40 micrograms of microcystin per kg body weight a day. The WHO divides this value by a factor of 1000 in order to obtain a TDI. This safety or extrapolation factor consists of components for taking into account the possible difference between laboratory animals and humans (10) and the variations in human susceptibility (10). A third factor of 10 is used because of the limited nature of the data, particularly relating to chronic toxicity and carcinogenicity. The TDI calculated in this way is 0.04 micrograms of microcystin per kg body weight a day. Given a body weight of 60 kg, the ingestion of two litres of water a day and the assumption that 80 per cent of microcystin is ingested via drinking water, the resulting recommended exposure limit for drinking water is (after rounding off) 1 microgram per litre. This TDI and the resulting recommended exposure limit for drinking water are derived subject to the principle that microcystin in drinking water should not result in any harmful effect, even after lifelong exposure. Assuming that a bather ingests 100 ml (twenty times less than the two litres of drinking water a day which is used for the calculation of the recommended exposure limit for drinking water), the WHO has calculated a recommended exposure limit for bathing water of 20 micrograms of microcystin per litre of bathing water.

When deriving the recommended exposure limit for bathing water from the limit for drinking water, the WHO assumes that exposure to microcystin in bathing water is also lifelong, in other words that there is exposure on a daily basis. This is a fairly conservative approach: it would seem to be more realistic to assume that there will be exposure on 35 days a year (a tenth of a year). On the other hand, the exposure level for children is higher in relative terms because of their low body weight and, furthermore, because they often ingest more water than adults.

The Committee is therefore of the opinion that there is no reason to depart from the recommended exposure limit proposed by the WHO of 20 micrograms of microcystin per litre of bathing water.

3.5 Non-compliance with the recommended exposure limit

A survey of 80 suspect lakes in the Netherlands in the early 1990s showed that, in almost half of the waters which were tested, cyanobacteria were dominant during the entire summer season, in other words that they were more numerous than the species of algae (Aqu00). The species of cyanobacteria which were found were *Microcystis*, *Anabaena*, *Aphanizomenon* and *Nodularia.* The survey did not include waters in which the cyanobacteria were only dominant during a short period of growth at the end of the summer. Only in 16 per cent of the waters were cyanobacteria not dominant at any time. *Planktothrix* was the leading species of dominant cyanobacteria, followed by *Microcystis*.

Toxicity varies in all the species referred to here. This means that toxic and non-toxic populations of a particular species can alternately displace one another in a single growing season. In a study of the relationship between the presence of cyanobacteria in recreational waters and the presence of microcystins, microcystin levels were measured at 48 sites in which cyanobacteria were dominant. At one in five sites, the levels were close to or in excess of the recommended exposure limit of 20 micrograms of microcystin per litre. Levels varied between the 48 sites from 0.15 to 147 micrograms per litre (Aqu00).

It can be expected that the health-based exposure limit will be exceeded in a reasonably large number of inland waters. If there is a surface bloom, there is a good chance that the recommended exposure limit will be exceeded. In countries other than the Netherlands, levels of microcystin in surface blooms have been measured of 24 milligrams per litre.

Chapter **4**

Trichobilharzia ocellata and Pseudomonas aeruginosa

4.1 Trichobilharzia ocellata (the agent of swimmer's itch)

4.1.1 General

Cercarial dermatitis (schistosoma dermatitis, swimmer's itch) is characterised by lumps which itch intensely, usually for no more than 12 hours. In people who are sensibilized, the symptoms can persist for a number of weeks and be accompanied by fever and headache. Swimmer's itch is caused by the penetration of the skin by the larvae (cercaria) of a particular bird parasite, the flatworm *Trichobilharzia ocellata*. The main source of the larvae in the Netherlands are pond snails which live in water and act as intermediate hosts for the parasite.

Every summer, there are reports of swimmer's itch which may lead to warnings from local GPs and the media, and the placing of warning signs (Lee00). The nuisance caused by swimmer's itch means that bathing water is closed to visitors. It is not possible to set recommended exposure limits here other than for the pathogens discussed in chapters 2 and 3. All one can do is take control measures to reduce the population of intermediate hosts in the water.

4.1.2 Trichobilharzia ocellata

In 1928, Cort found that the larvae of *Trichobilharzia ocellata* can cause dermatitis. Later, this was confirmed by others, such as Olivier (1949) and, in the Netherlands, Salomé (1953) and Bonsel et al. (1958). Salomé was the first author in the Netherlands to deal with this area (1953). The study used repeated infection tests to check whether the larvae found were indeed able to cause dermatitis.

The lifecycle of Trichobilharzia ocellata

The adult worms live in ducks and other water fowl (figure). The eggs exit with the faeces. In water, the eggs, with their characteristic shape, hatch and the released larva, which is known at this point in the life cycle as a *miracidium*, searches out suitable freshwater snails, which act as intermediate hosts. It penetrates the foot of the snail and, after a number of stages of development in the snail, cercaria emerge (referred to here as larvae), which are often released into the water thousands at a time. The positively phototropic larvae swim to the upper water layers, where they have to find a definitive host (ducks and other water fowl) within a day and penetrate into them through the feet and skin.

Transition from intermediate to definitive host

In Europe, the main intermediate hosts are pond snails (Gen96, Kol89). Pond snails are pulmonates which live in clear fresh water with relatively low acidity levels. Of the species which live in the Netherlands, the pond snail *Lymnaea stagnalis* and the oval pond snail *L. ovata* are the main intermediate hosts of *Trichobilharzia ocellata*. Laboratory experiments and field observations have both shown that it is possible to infect the ramshorn snail *Planorbis corneus* and the marsh snail *L. palustris*, but the level of larva production found was low (Slu83a). A field study showed that the large snails which released large numbers of larvae in the spring and summer were infected in the previous year (Lya77). These snails die in the summer and late summer. The snails of the following generation, which are particularly noticeable in the late summer as a result of the dying off of the old generation, will have been infected in the spring or early summer of the same year. These snails release fewer larvae than the big snails which live in the summer and early summer. However, after the winter, they will be responsible for the high levels of larva production in the following spring and summer.

Pond snails which host *Trichobilharzia* take longer to become sexually mature. Because growth and sexual maturity are inversely proportional, ‘giant growth’ results. Giant growth only happens if snails are infected at an early age (Joo64). Parasitised snails grow a few millimetres larger than non-parasitised snails (Slu80), the shells stays thinner and the tissues appear to be oedematous. Experimental infections have shown that young snails are particularly susceptible to infection. In the field, large pond snails (shell length up to 65 millimetres) stand out since they often live in the upper water layers. These animals are virtually all infected with parasites, including *Trichobilharzia* varieties.

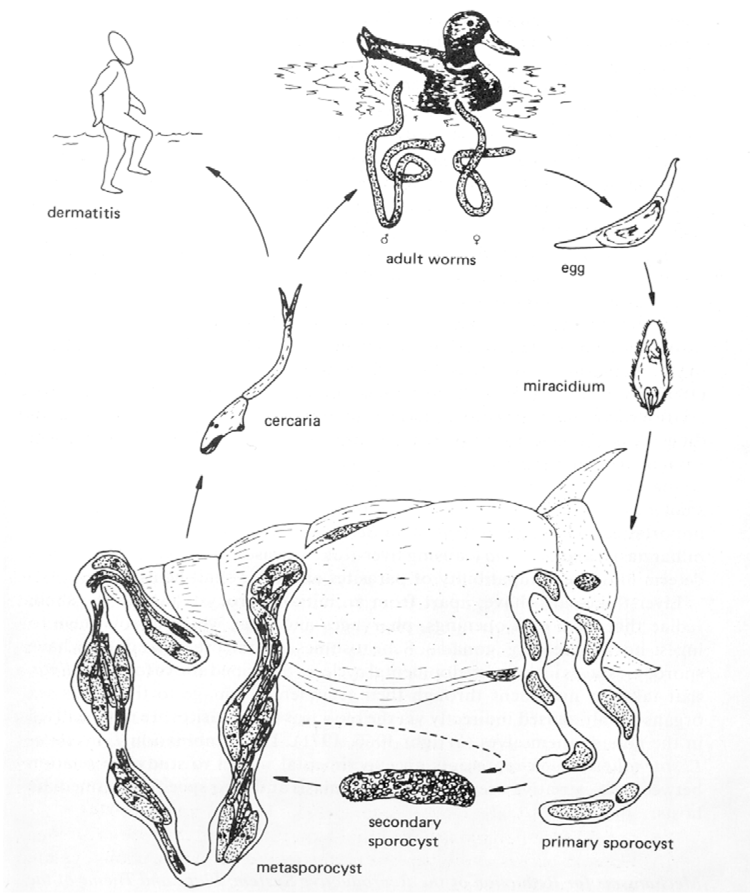

Figure The lifecycle of *Trichobilharzia ocellata.*

Larvae are released in the upper water layer. This increases the possibility of contact with the definitive host or bathers. Experimental infections of ducks have shown that their susceptibility to infection decreases rapidly with age. There is therefore a good chance of communicating infection when young ducks are in the water together with large numbers of larvae. The period between the development of the parasites in birds up to the time when the first parasite eggs exit with the faeces is approximately 14 days. The depositing of eggs by the snails starts in the early spring. So when most parasite eggs enter the water, there will be enough young snails which are susceptible to infection to act as intermediate hosts.

4.1.3 *Symptoms, diagnosis and treatment*

The first part of the term 'cercarial dermatitis' refers to the stage in the life cycle of the parasites when they penetrate into human skin. As far as we know, the head section of the larva (known after penetration as the 'schistosomulum') does not get further than the skin. The tail is jettisoned during penetration. The relatively long persistence of the skin symptoms at the site of penetration is an expression of the host response to the destruction of the larvae. Visible skin symptoms are associated with a pricking or itching sensation and disappear within 12 hours. If people are sensibilized, the symptoms may persist for between one to three weeks and be accompanied by headache and fever. In both cases, treatment focuses on reducing symptoms and consists of the local administration of an antihistamine or cortisone treatment.

4.2 Infections with human schistosomes

There is concern about whether infections with human schistosomes from the tropics could also occur in the Netherlands. These produce symptoms which are considerably more severe than those of swimmer's itch. Schistosomiasis caused by *Schistosoma mansoni*, *S. haematobium* or *S. intercalatum* has been found in travellers in the Netherlands and will also increase in step with growing global travel. The cycle is comparable to that of bird schistosomes but in this case humans are the definitive host.

It is unlikely that the development cycle of these parasites can be completed in the Netherlands. Each of the species of human schistosomes referred to has a specific tropical freshwater snail which acts as its own intermediate host. It is conceivable that these snails could enter our surface water via aquariums or ship ballast water. However, various factors make it improbable that the parasite will complete its development cycle. The use of sanitary facilities and the small numbers of people who are infected with the parasite mean that an infection of the intermediate host is unlikely. Furthermore, tropical snails can only survive in surface water if the temperature is high enough. Those temperatures are unusual in the Netherlands. It is extremely unlikely that all factors would be found together in a single location. As far as we know, a transmission focus for these parasites has never been found in other countries with a moderate climate.

4.3 Pseudomonas aeruginosa

General

The *Pseudomonas* genus includes a large number of oxygen-loving Gram-negative species of bacteria which are common in water and soil. For bathers, *Pseudomonas aeruginosa* is particularly important. These bacteria are found in numerous infections. Skin infections (the best known of which are folliculitis and otitis externa) have been found after bathing in swimming pools where insufficient chlorine has been used. Wound infections, sporadic urinary tract infections and airway infections are associated with *whirlpools* in particular. Otitis externa is an inflammation of the skin of the outer auditory canal in which the ear is sensitive and can itch. Of the disorders listed here caused by bathing in surface water, only otitis externa has been reported. Infection can be life-threatening on occasion, particularly among older people with diabetes or individuals with reduced immunity.

Epidemiological research

In the summer of 1994, GPs in the east of the Netherlands reported an increased incidence of otitis externa (Asp95). After four weeks, one in seven of those affected still had symptoms. A study was initiated, in which 98 patients and a control group of 150 people participated. This revealed a strong correlation between falling ill and exposure to recreational water in the two weeks prior to the presentation of the symptoms. *P. aeruginosa* was found in 80 per cent of the bathers with otitis externa, but in only 4 per cent of the control group. Further analysis showed that the risk was particularly high after bathing in bathing lakes, but not after bathing in chlorinated swimming pools, rivers or sea water. The risk of otitis externa increased with bathing frequency. For bathers in bathing lakes with a previous history of ear complaints, that risk was as much as 325 times higher than in the control group. In the bathing lakes, *P. aeruginosa* was found in one third of the samples. In a follow-up study after a swimming competition in Bussloo in recreational water with *P. aeruginosa*, ear complaints were only found in swimmers (Wit95).

The results of two American patient control studies corresponded to those of the study conducted in the eastern Netherlands. (Hoa75; Spr85).

Risk assessment

P. aeruginosa is omnipresent in aqueous environments and can be found in fresh water, salt water, swimming pool water and sewage. Effluent (from sewage treatment plants) contains 100 to 100 000 of these bacteria per litre (Gel99). High concentrations of *P. aeruginosa* are particularly common in stagnant, oxygen-rich, nutrient-rich and warm water. The results of research into Dutch surface water show that the concentrations are highest in July and August. *P. aeruginosa* was found in 14 to 45 per cent of seawater samples (Mat92; Yos87). In bathing lakes where there were epidemics in 1994, the concentrations of these bacteria varied from 0 to 100 per litre, with concentrations that were even higher at temperatures over 18ºC.

Little is known about the number of cases of otitis externa caused by bathing in surface water. In the records of provincial authorities and Municipal Health Services, only eight cases were reported per bathing season between 1997 and 1999. Given the common occurrence of *P. aeruginosa* and the numbers of cases of otitis externa found in specific studies during an epidemic in 1994, the registration system would seem to be underreporting the number of cases.

There is no relationship between the concentration of *P. aeruginosa* and faecal contamination. The current standards for faecal contamination provide no protection against *P. aeruginosa*. Attempts have been made using epidemiological research to quantify the link between the concentration of *P. aeruginosa* and the incidence of symptoms. Because of the variation in that concentration (even over short periods of time and small distances) and the variation in the level of exposure, there is no clear dose-effect relationship. It is clear that high concentrations of *P. aeruginosa* can occur at water temperatures over 18ºC.

Chapter 5

Leptospira, Clostridium botulinum, Naegleria fowleri and Acanthamoebae

Unlike the other infectious diseases discussed above, infections with other pathogens can be severe or even fatal. Weil's syndrome and botulism are covered by the Infectious Diseases Act (category C and category B, respectively) and are notifiable. That is not the case for the amoebae *Naegleria fowleri* and acanthamoebae.

5.1 Leptospira (including the agent of Weil's syndrome)

Leptospira are spirochetes and are widespread in water. Leptospira can be classified on the basis of their serological characteristics in serovars (serovarieties). We now know of more than 200 serovars which can cause leptospirosis. The serovars *L. icterohaemorrhagiae* and *L. copenhageni* can cause a severe form of leptospirosis, Weil's syndrome. Although each pathogenic serovar can cause a severe or mild form of leptospirosis, the serovars *L. grippotyphosa* and *L. hardjo*, for example, generally result in less severe forms of leptospirosis: water fever and dairy worker fever respectively. The main reservoir for the serovars *L. icterohaemorrhagiae* and *L. copenhageni* are rats, with the reservoirs for the serovars *L. grippotyphosa* and *L. hardjo* being mice and cattle respectively. In the host, leptospira live in the kidneys and are excreted in the urine. In favourable conditions, leptospira can survive for days or weeks, and sometimes even months, in fresh water or in mud. The optimal circumstances are a water temperature of 25-30°C and slightly alkaline acidity levels. In salt water, leptospira die quite quickly.

Transmission

The main transmission route is through contact with water. The victims among recreationists are therefore bathers, canoeists and surfers. Transmission takes place after direct contact with the urine, blood or tissue of infected animals or after exposure to a contaminated environment. Touching dead animals or mammals, or contact with urine on banks, are therefore possible routes. Infection takes place through skin lesions or mucous membranes. The leptospira excreted in urine can survive in water for some months.

Rats are the best-known reservoir of leptospira. Leptospira can also enter water via other mammals such as mice and dogs. It should be pointed out that dogs are usually vaccinated against leptospirosis, but this protection does not apply to all serovars.

Disease, diagnosis and treatment

With the increase in water recreation — not only at home but also on holidays in countries such as Thailand, Malaysia, Costa Rica and the United States — the number of cases of leptospirosis is also on the increase. Some of the cases are not registered since the symptoms are subclinical or because there are only flu-like symptoms. The annual total is about forty cases of severe leptospirosis in the Netherlands, approximately half of which are contracted abroad. Most patients have a mild form of the disease, which also passes off without treatment. One in ten cases are severe, resulting in referral to a specialist or hospital admission. The diagnosis 'leptospirosis' is awkward because of the variation in symptoms, which can present in different combinations, and because of the difficulty of the laboratory tests. There is probably underreporting of severe forms of leptospirosis. Leptospirosis is generally accompanied by clotting disorders so that these patients often have bruises or pulmonary haemorrhage. Other symptoms are flu-like symptoms, cramp (particularly in the calves), a stiff neck and headaches. Weil's syndrome is caused by the serovars *L. icterohaemorrhagiae* and *L. copenhageni*. Often, but not always, this results in characteristic haemorrhaging and liver and kidney failure. Other serovars can also cause Weil's syndrome. Between one third and half of the group with severe symptoms die. This equates to a few deaths annually.

A problem with laboratory research is that the antibodies for leptospira can only be identified 7 to 10 days after the infection, while treatment with antibiotics has to start within five days in order to be effective. The microscopic agglutination test (MAT) is the standard test method. An ELISA test provides supplementary information.

Therapy consists primarily of penicillin or doxycycline. Depending on the severity of the illness, it is administered orally or intravenously.

5.2 Clostridium botulinum

C. botulinum is a spore-forming bacteria which can be found anywhere in the environment, particularly in sediment. In general, exposure to the spores is not dangerous. The spores of these bacteria can only grow in a protein-rich animal substrate consisting of, for example, dead fish or ducks. In those conditions, the bacteria produce toxins (botulin) which, in very small quantities, can be fatal to humans or animals. The main route of entry for the toxins into the body is via the mouth. Botulin is one of the most toxic substances there is. When administered in the artery of a mouse, this neurotoxin is deadly at a dose of only 20 picograms. In humans, the first symptoms appear within 12 to 24 hours. The main symptoms are paralysis symptoms which first manifest themselves as blurred vision, and difficulties with talking and swallowing. The nerves of the peripheral nervous system are then blocked, leading to the paralysis of arms, legs and neck, followed by paralysis of the respiratory muscles. There are various types of botulin (A to G).

In the Netherlands in recent decades, there has only been one known case of suspected botulism. The possible source was contaminated food. There are no known cases in the Netherlands of botulism caused by water recreation. The strain responsible for type E botulin in dead fish is particularly dangerous for humans. It should be pointed out that optimal growth and toxin production is only found at temperatures in excess of 20°C and acidity between 6 and 7. Breakdown of the toxin in the environment is generally rapid. In dead ducks, type C is the main toxin and it is much less dangerous for humans than the type E toxin.

It is only in the immediate proximity of dead animals (fish) that toxin concentrations are high enough to cause symptoms of poisoning in humans. Contact with dead animals should therefore be avoided. The bacteria can be spread if other animals eat the cadavers. Immediate removal of dead fish and ducks as required by law in the Netherlands (Dry Rendering Act) would appear to be an adequate safeguard against botulism in bathers.

5.3 Naegleria fowleri

Naegleria fowleri is a free-living amoeba (a single-cell micro-organism), mainly found in warm fresh water at temperatures below 45ºC. The optimal temperature for this pathogen is close to human body temperature. In general, higher temperatures seem to be more beneficial to pathogenic species than to non-pathogenic species. Infection with *Naegleria fowleri* can cause primary amoebic meningoencephalitis (PAM), an infection which is usually fatal within 3-7 days after the presentation of the initial symptoms. Other *Naegleria* species do not cause PAM. The disease is fortunately rare. PAM is primarily contracted by children and young adults who have been in contact with fresh water shortly before. Most infections take place in a warm tropical or subtropical environment. Virulent strains have been isolated from lakes with water temperatures between 14 and 35ºC. Cysts, which are formed during warm summers, can probably survive the winter and are able to grow again the next summer (Bid84). There have been no known cases of PAM in the Netherlands. In Belgium, four cases in indoor chlorinated swimming pools have been reported, as well as one case after bathing in thermally-polluted surface water. A similar case involving thermal pollution was also reported in Poland (Jon77). Although most infections in Europe occurred in indoor, heated swimming pools, reports from the USA were mainly of cases after bathing in the warm lakes of Florida and California. In Australia also, infections have been reported in which the source was thought to be the drinking water systems. The literature points out that thermally-polluted surface water should not be used for sports or other recreational activities (Cer82, Hui90). In the Netherlands, *N. fowleri* is found in cooling water from power stations (Koo85). These organisms are also found regularly in cooling water in Belgium and France (Jon77, Div81).

Naegleria fowleri occurs as a trophozoite and as a cyst. The trophozoite occurs in two forms: a amoeboid form on solid surfaces and a flagellate which can swim freely in water and therefore increase the possibility of contact. Cysts can survive for a long time in natural surroundings. The amoeboid trophozoite measures 10 to 35 micrometres and feeds on common bacteria. After 8 months at 4ºC, cysts still produced symptoms in mice. At temperatures higher than 23ºC, amoeboid trophozoites which live on sediment can transform themselves into flagellates. Bathers are therefore mainly exposed to this form of the parasite.

Infection takes place through the nasal mucous membrane. In amoeboid form, the trophozoite passes through the roof of the nose and spreads mainly in the basal area of the brain. The result is an acute necrotic encephalitis. After an incubation period of two to ten days, the patient suddenly starts with headache and fever. From this point onwards, the patient’s condition worsens rapidly and the symptoms extend to include irritation and inflammation of the cerebral membranes and the brain. The patient goes into coma and dies three to seven days after presentation of the initial symptoms.

5.4 Acanthamoebae and Balamuthia mandrillaris

These amoebae can, like the *Naegleria* species, reproduce freely in natural conditions. They can be found in water and optimal growth occurs at between 25 and 35ºC. They form cysts which can survive for long periods and which are also found in human tissue in patients. Unlike *Naegleria*, they result in a more chronic form of encephalitis, granulomatous amoebic encephalitis (GAE) which, like PAM, is usually fatal. These are opportunistic parasites which attack people with reduced immunity caused, for example, by a transplant or AIDS. They probably enter the body through the respiratory system or a skin lesion. They reach the brain through the blood.

In 1997, 166 cases had been reported worldwide, 103 of which were caused by acanthamoebae and 63 by *Balamuthia* (Mar97). Contact with water does not appear to play a role in causing the disease. No proven infections have been found in the Netherlands. Ocular inflammation can also be caused by acanthamoebae. Here also, these infections only occur after the amoebae have gained access to tissue through a damaged part of the cornea. The result is a chronic inflammation of the eye known as amoebic keratitis. This is awkward to treat and can result in blindness. Amoebic keratitis is found particularly among wearers of contact lenses. In the Netherlands, — depending on the type of contact lens — severe microbial keratitis is contracted by one to twenty wearers of contact lenses per 10 000. *Acanthamoeba* is the pathogen in a small proportion of these cases (GR01). The possibility cannot be excluded that infections of this kind result from contact with amoebae in bathing water, but no cases of this have yet been found.

There is no data available about the levels of *Acanthamoeba* and *Balamuthia* species in surface water in the Netherlands or the neighbouring countries. Given the global spread of the species, it is reasonable to suppose that these amoebae also occur in the Netherlands. Thermally-polluted water is, given the preferred temperatures of these amoebae, a possible reservoir.

Chapter **6**

Control measures: the safety chain

The Committee now turns to control measures for recreational water based on a ‘safety chain’. After presenting the model, it looks at how current legislation and environment policy fit into it. The Committee then looks at the use of the safety chain for recreational water. In doing so, it also makes a start on answering the questions from the Minister about control measures and communications relating to risks. In chapter 7, the Committee elaborates the safety chain for the individual pathogens, linking the proposed recommended exposure limits to specific measures, depending on the nature of the effect.

6.1 The safety chain in brief

The safety chain includes the following stages:

- Proaction (making infection impossible): for example by not designating a particular surface water as bathing water.
- Prevention: for example, by moving or isolating overflows located in the vicinity, making sure that water circulation is satisfactory and limiting eutrophication.
- Preparation: preparations for control measures, for example inspections, measurements, and appraisals using reference values.
- Repression: taking action when reference values are exceeded. These measures can focus on the source, an example being the removal of surface blooms, but they usually target the public. The three usual public measures are: information, advice and prohibition.

- Aftercare: repairing damage, in this case by means of medical treatment.

The chain is intended to be a circular sequence of control measures. After follow-up, it returns to assessing the suitability of bathing water for recreation. Before the Committee discusses the individual links in the chain, it will look at how current legislation and prevailing environment policy fit into the safety chain.

6.2 Legislation and the standards framework

Since 1976, the directive for the quality of bathing water (surface water and coastal waters) has applied to the EU member states. This directive contains requirements relating to water quality, the water quality parameters for analysis, and the prescribed monitoring frequency and reporting requirements. In the Netherlands, this directive has been implemented in two decrees (orders in council) based on the Safety and Hygiene in Bathing Establishments and Swimming Pools (Hygiene & Safety) Act and the Pollution of Surface Waters Act. The Swimming Pools (Hygiene & Safety) Act includes, for example, the statutory environmental quality objectives and regulations for bathing water. Pursuant to this act, provincial authorities are responsible for enforcement, supervision, exemptions, closure and the drafting of detailed regulations. The Quality Objectives and Surface Water Measurements Decree based on the Pollution of Surface Water Act focuses primarily on the water authorities and includes the non-statutory quality objectives for surface water which is used as ‘bathing water’. These quality objectives were originally, with a view to cleanup operations, stricter in a number of respects than the statutory EU standards, but they were later harmonised to come into line with the standards in the Swimming Pools (Hygiene & Safety) Act. The main parameters for bathing water quality are the indicators of faecal contamination, general quality features (transparency, acidity, oxygen), certain chemical pollutants and a few other characteristics such as smell and the presence of foam or dirt.

In addition, the Infectious Diseases Act (of 1998) includes provisions for action to combat diseases caused by pathogens for which there are no standards in bathing water, such as leptospira (including the agents of Weil’s syndrome) or *C. botulinum*. The mayor is the competent authority for taking such action and the Municipal Health Service has an advisory role. Furthermore, the Dry Rendering Act requires animal cadavers to be removed immediately in order to prevent infectious diseases.

In the policy document ‘Premises for Risk Management’, the Ministry of Housing, Spatial Planning and the Environment elaborated basic principles for setting standards in environment policy. In addition to substances, this was also done for noise and smell (TK89). The environment policy is based on the goal of sustainable development in which people, animals, plants, ecosystems and goods are protected. The policy may focus on either the source or the effect.

The basic principle of source-oriented policy is the prevention of unnecessary pollution. For this purpose, the ALARA principle (*as low as reasonably achievable*) can be used. This states that care should be taken to offset the benefits of additional risk reduction against the social and economic expenses involved in achieving that reduction (GR95). The basic principle of the effect-oriented policy is that the risk of adverse effects on humans, for example, should be as low as possible. The government lays down in a 'risk limit', a level of protection which must be achieved or set as a target. The request for an advisory report (annex A) states a maximum permissible risk of one infection per 10 000 individuals per year.

Both the legislation and the effect-oriented policy are mainly concerned with the 'preparation' and 'repression' links. The basic principles of the source-oriented policy do include possibilities for the other links of the chain, but they have not been elaborated in further detail for recreational water. It is expected that the new EU bathing water directive will place more emphasis on the initial links of the chain than on repression (non-compliance with standards). One control instrument being considered by the EU is the drafting of risk profiles for bathing sites. A profile of this kind requires a survey of the sources and conditions which are relevant for any risks.

6.3 Bathing water quality and the safety chain

The Committee believes that the safety policy for recreational water should include all the links in the safety chain. An important principle in that respect is that measures should be taken as early in the chain as possible in accordance with the principle that prevention is better than cure. In general (but certainly not always), the further along the safety chain one gets, the more serious the situation has to be before action is taken. This section is a first step towards establishing measures for each link. In later sections, the Committee elaborates the measures for each pathogen or group of pathogens.

Proaction

'Proaction' includes measures to prevent people bathing, for example by not building a recreational body of water if health risks can be anticipated. An important form of proaction identified by the Committee is the inclusion of sites designated as 'bathing water' on maps with bathing sites drawn up by the provincial authorities. Microbial pollution should be an important criterion here. An overview of waters which are suitable as bathing water is not only useful in this respect but also, for example, in terms of encouraging preventive measures and for public information activities (passive or otherwise). The Committee believes that the risk profiles referred to above should be used as a basis for deciding about suitability as bathing water. This profile should include the following elements:

- The result of past measurements of pathogens. This involves mapping out not only trends in microbiological quality (what are the quality levels during the course of the season?) but also incidental increases.
- A survey of sources of microbial pollution and the associated risks.
- A survey of cases of illness associated with the bathing water in question.
- The presence of risk-bearing activities such as shipping and chemical pollution, of physical agents such as glass and metal, and of currents.

If a body of water scores well for all components of the risk profile, it is designated as being ‘suitable as bathing water’. If sources are present, if recommended exposure limits are exceeded or if there is an unacceptable risk, preventive measures are required at all times. Putting this aside, the Committee believes that a control plan should be drawn up at this stage which elaborates the measures in the others four links of the chain.

Prevention

Good management of bathing water can make a major contribution to the prevention of microbial pollution. Preventive measures can be broken down into: standard measures (which should always be taken) and additional measures, in accordance with the results of measurements, visual inspection or observed complaints. If a site has been designated as ‘bathing water’, there should always be monitoring of certain pathogens. If the risk profile shows that there is a particular risk, further investigation is required to obtain more information about the nature of the sources and therefore the duration of the risk. In this respect, the efforts made should be in proportion to the category and the extent of the risk. In all cases, the result of the measurements must be linked to the possible inclusion of the site on the list of suitable bathing water sites (see also under proaction).

Preparation

Preparation is a special link in the safety chain because it consists of preparation for repression. It is mainly a question of the availability of people, materials, and methods or procedures. In particular, the last element in this list requires elaboration. The Committee has in mind measurements and inspections, assessment criteria and control measures based on the assessment. The measurements, inspections and criteria should preferably match those used in the proaction and prevention stages.

Repression

When reference values are exceeded, measures are required which focus on both the source (such as the removal of surface blooms) and on bathers. The three usual public measures are: information, advice and prohibition. This breakdown also corresponds to levels of severity. The Committee advocates reticence with respect to information activities if the risk is acceptable. In practice, it has emerged that people only want information if there is a real problem.

In certain situations, it is questionable whether a ban will be desirable and it is possible that providing advice or information will be sufficient. This is the case when a site has been designated as bathing water during the proactive phase, when the health risk is relatively minor and when there is enough information on the site for people to make an informed decision. A difficulty here is that children are not able to make decisions of this kind. To a certain extent, therefore, people involved in policy for bathing sites must act in loco parentis in these circumstances. A recommendation can only be observed or disregarded after the facts have been considered. The decision to engage in a particular activity involving risk is not purely rational but much more the result of a social process. The result could be a situation in which, if there are two sites with signs advising people not to bathe, one site may be very busy and the other deserted. If a ban is not enforced, it effectively becomes a recommendation. In the Netherlands, there is a lot of experience with the tolerance of infringements of this kind. The decision about whether to introduce a ban is therefore also linked to the efficacy of a ban: is the risk which has been observed actually eliminated? A problem here is that there can sometimes be a long period of time between the taking of the first sample and the introduction of a ban. It may, for example, be the case that there has been a considerable reduction in the risk by the time the ban is introduced. Other important factors here are the representativity of the sample and the reproducibility of the measurements.

People’s wish to be bothered as little as possible and their need for clarity mean that the number of measures should be kept to a minimum. Any measures intended to allow people to make their own assessments are problematical when bathing water is involved. A possible exception here are certain risk groups but the information provided to these people should not be given at the site but by their GP or specialist (see chapter 8). In most cases, information is only useful for reassuring people if there is something unusual but if bathing is still possible. It can also be useful to provide information if a site has wrongly been described as suspect by the media or in rumours. However, there is little point — and it is in effect an unnecessary burden — in informing people about risks if preventing them from bathing is not an urgent necessity. Passive communications are a more obvious step. The people who want to know more about the risks of bathing should be able to find that information without difficulty on, for example, a government web site.

At most, the information provided actively at the site itself should be very neutral. This could be done in the form of a sign at all bathing sites carrying, for example, the following text:

> Bathing can cause health problems such as diarrhoea, nausea and skin complaints. Consult your GP about any symptoms. For more information about the risks of bathing...

As has just been pointed out, it is not advisable to provide information for people to use as a basis for their own decisions. An alternative to a ban could be a measure occupying the middle ground between advising people what to do and a ban telling them what not to do, namely dissuasion. A breakdown into two categories would therefore appear to be the most suitable approach to control measures in addition to a ban: passive information activities (as well as, where appropriate, neutral active information activities) or advising against certain activities. This could consist of a sign carrying the text:

> Do not bathe. X found.

This negative advice could be brought to the attention of minors again. The Committee is of the opinion that bans should be introduced only in very exceptional circumstances but that they should also be enforced. The Committee believes that this also depends on the nature of the effect of exposure to the pathogen concerned. In chapter 7, the Committee lists the pathogens and groups of pathogens for which a ban is desirable.

Aftercare

Aftercare here means repairing damage. For bathing water, aftercare mainly consists of medical treatment. In most cases (gastro-enteritis), GPs can provide this treatment without additional information. It is only in exceptional circumstances that it will be necessary to inform GPs about unusual disorders and appropriate treatments. Part of aftercare consists of determining the causes of incidents or non-compliance and the extent to which proactive measures are required.

Conclusion

The Committee believes that the control measures in the five links of the safety chain constitute a comprehensive system based on more than just prohibitions. The decision about whether to designate water as bathing water on a provincial map using a risk profile, and the drafting of a control plan, are regarded by the Committee as the most important links in this chain. This emphasis on the early stages in the chain is appropriate for the, generally speaking, relatively minor nature of the effects of microbial contamination of bathing water. The safety net at the end of the chain, for example on the basis of the Infectious Diseases Act, is adequate.

Chapter 7

The safety chain for individual pathogens

The Committee will now turn to the measures relating to the individual pathogens discussed in chapters 3 to 5. The Committee believes that all the links in the safety chain should be gone through for both faecal contamination and cyanobacteria, with the emphasis being placed on the initial stages. In the cases of *Pseudomonas aeruginosa*, leptospira, *Clostridium botulinum, Acanthamoeba, Balamuthia mandrillaris* and *Naegleria fowleri*, the value of the safety chain is more limited because preventive measures are adequate or because intervention is only required when there are incidents. The Committee believes that the agent of swimmer's itch is located between these two extremes: it is not necessary to go through all the links in the safety chain in all cases.

7.1 Faecal contamination

Proaction

The risk profile should, as pointed out above (6.3), include the following elements for pathogens:

- The results of past measurements of pathogen indicators. These will, generally speaking, be available. For recreational waters, there is a statutory obligation to measure the concentrations of indicators of faecal contamination at least twice a week during the bathing season.
- A survey of sources and the associated risks. The main sources are: the run-off of manure from livestock farming areas, the proximity of sewage overflows and

effluent discharges, the bathers themselves and the presence of bird colonies in the bathing season.
- The cases of illness attributable to the bathing water in question. In practice, it has proven to be very difficult to link incidents, even if they are registered at all, to faecal contamination in a water. If relevant information is available, it should be included in the risk profile.

The risk profile shows whether a site is suitable as bathing water. Here, it is sensible to use measurement results from previous years to make a distinction between burdened and unburdened situations. In an unburdened situation, there are no active sources such as large numbers of visitors or overflows. In a burdened situation, there are. This distinction is the basis for a decision about whether a bathing water is designated as being suitable for that purpose:

- The water meets the standards in both the burdened and unburdened situations: the bathing water is approved for use as bathing water.
- The water meets the standards in the unburdened situation but not in the burdened situation: the water is provisionally approved as bathing water, but preventive measures and further research are required.
- The water fails to meet the standards in both the burdened and unburdened situation: the water is not approved as bathing water, local action and further research are required.

Prevention

The Committee does not believe that the proximity of overflows or discharges of effluent are compatible with the function of bathing water. It believes that it is urgently necessary, where possible, to move these sources to other waters. The concept of ‘proximity’ is awkward to define. The complex hydrology of surface water is difficult to predict. For example, pollution spreads differently in stagnant water and flowing water. Furthermore, it is important to determine the conditions in which overflows are located in terms of frequencies and amounts (expressed in absolute quantities and the concentrations of indicators of faecal contamination). Steps should then be taken to determine the extent of the influence of overflows on a particular water. Indications of the effect of overflows can be found by combining the measurement results for faecal contamination at the bathing site with precipitation data. The presence of large numbers of visitors may be a major source of pollution. In order to determine whether this is the case, samples should be taken later in the day. Information about the number of visitors is also important because it determines the number of cases of illness. The Committee believes that large numbers of visitors require greater efforts from supervisory agencies.

Preparation

In the preparatory phase, procedures are developed in preparation for possible repressive measures. Reviews are conducted to determine what information is required as a basis for repressive measures. The focus here is on criteria for assessing the standard and on interpreting the results of the monitoring activities conducted previously.

The problems with the current assessment criteria relate particularly to the reproducibility and representativity of the concentrations measured. The Committee believes that the current measurement method, in which only a single sample is taken once every two weeks at one site, is inadequate to determine the level of pollution. Nor is the Committee in favour of the current repeat sampling procedure which follows after an infringement has been found. In the past, this repeat sample was taken largely because of the limited reliability of measurement methods. However, current measurement methods are standardised (in accordance with an NEN standard) and are reliable enough for analysis purposes. A repeat sample procedure results in action being delayed unnecessarily. Because of the frequency of measurements and the fact that action is only taken after repeat sampling, there is a considerable risk that, on the one hand, action will only be taken when it is no longer required and, on the other hand, that most people will have already been taken ill before the action has been taken.

It is important not only to carry out measurements which establish a picture of the general quality of the water (the unburdened situation) but also to track down incidents and to actually carry out measurements in those places where the risk is highest. The measurement frequency should be higher when there are high densities of bathers at sites with little or no water circulation, after heavy rainfall if there are overflows, or if the recommended exposure limits have been exceeded recently or regularly. An understanding of the dynamics is important if the correct action (particularly repression) is to be taken. To prevent disease, action must be taken immediately after non-compliance has been observed. Further investigation will then be required to trace the sources of faecal contamination and check whether the contamination is still taking place and whether the measures should remain in place.

At present, the Committee considers a composite sample from ten sites to be the minimum requirement. Studies of variations in faecal contamination are required to establish the best sampling strategy for the purposes of proper action. In one study discussed above, there was a factor of 10 in spatial variations, measured in the immediate proximity of bathers (Asp98). There is no information available about variations in concentrations of indicators at different sites in the Netherlands. Major variations in time can be expected at sites with large numbers of visitors and stagnant water. It can be assumed that the concentration will increase during the day. Measurements should not therefore be carried out early in the day.

The Committee wishes to draw attention to the fact that proaction and prevention also result in an understanding of how to assess non-compliance.

Repression

When a recommended exposure limit is exceeded, further investigation is important. Continued monitoring of the concentration of indicators in order to determine whether the risk is still present and the search for possible causes (sources) of non-compliance play a central role here. As pointed out above (chapter 6), the Committee is only in favour of bans in exceptional circumstances. This is linked to the nature of the effect. With faecal contamination, the main effect consists of common gastrointestinal complaints. Given the degree of severity of these complaints, the Committee believes that a cautious approach to imposing bans is desirable. If the current policy of the EU is maintained, there will be a directive which requires the introduction of a ban in cases of non-compliance with the EU standard. If this standard is stricter than the recommended exposure limit proposed by the Committee, the Committee advocates advising the public not to bathe if the values are located in the intermediate range of concentrations.

7.2 Cyanobacteria

Cyanobacteria are commonly found in large numbers in surface water. The effect of exposure to cyanobacteria (and the toxins they produce) is generally more severe in nature than the effect of exposure to faecal contamination. The Committee therefore believes that cyanobacteria merit at least as much attention as faecal contamination.

Proaction

The risk profile for cyanobacteria should include the same elements as those described above (in 7.1) for faecal contamination.

- The result of past measurements of cyanobacteria and the toxins they produce. The occurrence of surface blooms as determined by inspections, microscopic identification of the main toxin-producing species and determination of microcystin levels. The Committee believes that a lot of information is available at a large number of water authorities about the presence of cyanobacteria.
- A survey of the level of eutrophication in the water. The presence of large quantities of cyanobacteria is linked to the amount of nutrients in the water.
- A survey of cases of illness which can be attributed to bathing water. In practice, it has proven to be very difficult to link incidents, even if they are registered at all, to

exposure to cyanobacteria. Either the symptoms are not very specific (gastro-enteritis and skin complaints) or difficult to trace (liver damage). Cases of illness will therefore not be readily blamed on exposure to cyanobacteria. A survey of the effects on pets and agricultural animals exposed to cyanobacteria in the bathing water in question provides useful supplementary information.

Proaction may also mean that the design of a water will take into account the prevailing wind direction, which moves the surface blooms into a particular section of the water.

If surface blooms are common, a site should not be designated as being ‘suitable as bathing water’. A complication in this respect is that the prevention of surface blooms depends to a very large extent on summer temperatures.

When there are reports of illness, surface blooms or high concentrations of microcystin, there should be extensive monitoring in the prevention phase. This is also the case if information about the presence of cyanobacteria is inadequate.

Prevention

This link involves mapping out the main genera and species of cyanobacteria and establishing toxin concentrations. The first of these activities involves microscopic research. Toxin measurement is required because the presence of toxin-producing species does not necessarily mean that the toxins are actually present. In order to prevent incidents, it is important to map out trends in the occurrence of cyanobacteria. This would make it possible to answer questions such as: how do species proliferate in the bathing season and in what conditions (temperature, eutrophication, depth of the water, wind direction)?

The main preventive measure is the reduction of eutrophication in a water. It is only in exceptional circumstances that the introduction of artificial circulation by means of aeration will be considered (deep lakes with a lot of recreational activity). In addition, it is sensible to advise the public to rinse themselves off (with mains water) after bathing. This can help to prevent skin problems.

Preparation

Because high levels of eutrophication need not necessarily mean that cyanobacteria are present in large numbers, regular microscopic analysis is the most appropriate approach. This is also true of waters in which the concentration of chlorophyll (in a composite sample) is higher than 10 micrograms per litre. If it should emerge that cyanobacteria are dominant, it will be necessary to determine the concentration of microcystin.

Monitoring during the course of the season will be required in waters in which there has been cyanobacteria dominance. Because there can be rapid changes in the toxicity of the bacteria, the microcystin concentration should be determined every two weeks during that period.

Repression

When there are surface blooms, a ban on bathing will be required because toxin concentrations can be very high. After the introduction of a ban, it is important to determine the microcystin concentration in the surface bloom. Toxin levels in surface blooms are not always high. If the microcystin concentration is below the recommended exposure limit, the Committee would prefer advising against bathing because high LPS concentrations are by definition present in surface blooms and they can cause skin irritation and disorders. A complication involved in a bathing ban associated with surface blooms is that these surface blooms can be moved very quickly by the wind or dissolve in the water. In these cases (after the microcystin concentration has been measured), it would be possible to suspend the bathing ban.

If the microcystin concentration is higher than the recommended exposure limit proposed by the Committee, a bathing ban should be introduced for the bathing water in question.

7.3 Trichobilharzia ocellata (the agent of swimmer's itch)

Swimmer's itch is not a major public health problem, even though it does result in the utilisation of care services. Because of the nuisance caused by swimmer's itch, a bathing water may — perhaps temporarily — lose the designation 'suitable as bathing water'. The presence of pond snails and the prevention of cases of swimmer's itch determine the control measures to be introduced. In annex C, the Committee presents a flowchart for the measures to be taken in various situations. It makes a distinction there between existing and new bathing water.

Proaction

If pond snails are present and if there are cases of swimmer's itch, the site should not be designated as being 'suitable as bathing water'. In other cases, prevention, preparation or repression may be appropriate. It is advisable to determine whether there have been cases of swimmer's itch over the course of a number of years. Depending on the conditions, swimmer's itch need not necessarily occur every year. The infection of snails in the spring or early summer may possibly cause swimmer's itch the year after. Whether or not snails become infected depends on the presence of infected water fowl.

Prevention

Possible targets for prevention control measures are the intermediate host and the definitive host. In practice, it is not usually possible to eliminate water fowl from recreational water. There are therefore few openings for reducing incidence in this way.

The elimination of the intermediate host (pond snails) is an approach with more potential. Non-chemical options for reducing the snail population are: collecting snails from the area, introducing snail-eating species of fish and removing aquatic flora. The literature shows that the incidence of swimmer's itch is linked to the presence of clear, relatively shallow water.

In the Netherlands, experience has been acquired in six sites with the mechanical removal of aquatic flora or the introduction of a range of snail-eating species of fish (Don88). The Committee does not believe that it is possible to distinguish adequately between the various factors which determine the efficacy of the measures in these six sites to justify advising the control measures referred to here. Collecting snails from an area would appear to be the most appropriate method. In the case of new bathing water, the goal will be to prevent the establishment of what is virtually a monoculture of pond snails because infection of those snails with the parasite will result in a major risk of swimmer's itch. The chance of this happening and the possibility of a large number of infections increases in proportion to the number of water fowl in the vicinity. It can therefore be advisable to remove the pond snails twice a year: the old generation in the spring and the new generation in August. It is probably not possible to eliminate all cases of swimmer's itch but it is possible to keep the number of cases under control.

It has been suggested in the literature that the use of suntan cream could have a preventive effect. The theory is that the cream would prevent larva penetration but there are doubts about the effect (All94). Larvae in an aqueous environment need four to ten minutes to penetrate (Oli49). The larvae are therefore thought to penetrate into the skin mainly during bathing. It is advisable to dry oneself off immediately after bathing in order to remove any larvae present on the skin but the effect will be limited.

Preparation

It is important to determine what species are present in areas where snails live. If the pond snails (*L. ovata* and *L. stagnalis*) are present, swimmer's itch is a possibility. It should be pointed out that identifying the different types of snails is a job for experts. Determining whether the snails are infected is a simple matter. It consists of putting about ten snails in a glass jar in oxygen-rich water (oxygen-rich water can be obtained, for example, by pouring the water into the jar from a height). The jar is put into the sun or under a light. The schistosomes released can be seen as a cloud. Microscopic analysis will show definitively whether they are schistosomes: they have forked tails and two eyespots.

Repression

As pointed out above, collecting snails is the most effective way of tackling the source. If action is not practical or if — despite the action taken — the number of cases does not fall, a ban on bathing is justified. This may also be a reason to warn local GPs.

7.4 Pseudomonas aeruginosa

Control measures for reducing the natural levels of *Pseudomonas aeruginosa* are virtually impossible. The only option from the point of view of the safety chain is repression. If, as a result of bathing in a particular water, there is a sharp increase in the incidence of otitis externa and if the temperature of the water is 18°C or more, consideration may be given to advising against bathing there. In addition, it is important to warn people who are at an increased risk of otitis externa, such as people with a prior history of chronic ear complaints.

7.5 Leptospira

Repressive measures are only required for leptospira when there are incidents. If there are cases of leptospirosis which can be traced back to a particular bathing water site, that site must be closed and deprived of its designation as bathing water. This should at least be done until the necessary preventive action has been taken. Controlling sources of leptospira such as rats by means of good hygiene at the site (waste removal) is one example of action of this kind. In general, there is no point in establishing the presence of leptospira in water. They may be non-pathogenic leptospira. Infection with leptospira may be very local and difficult to trace.

7.6 Clostridium botulinum

As pointed out above (5.2), there have in recent decades been no cases of botulism as a result of exposure to bathing water. The Committee concludes from this that preventive measures pursuant to the Dry Rendering Act are adequate and should be kept in place. These measures involve the removal as quickly as possible of dead fish and waterfowl. Should there nevertheless be a case of botulism which can be traced to a particular bathing water, a bathing ban should be introduced using the provisions of the Infectious Diseases Act. A warning against touching dead animals is also advisable.

7.7 Naegleria fowleri, Acanthamoeba and Balamuthia mandrillaris

In view of the severity of the diseases which these amoebae can cause, recreation in water where cooling water discharges have a direct effect should be forbidden.

Chapter **8**

Replies to the questions

Question 1

Which pathogens are of relevance in terms of the risk of bathing in surface water?

Answer

The main pathogens, which were discussed in chapters 2 to 5, are: pathogens from faecal contamination, cyanobacteria, *Trichobilharzia ocellata* (the agent of swimmer's itch), *Pseudomonas aeruginosa, Naegleria fowleri, Acanthamoeba, Balamuthia mandrillaris, Clostridium botulinum, and leptospira* (including the agent of Weil's syndrome). There are numerous other pathogens in recreational water such as other micro-organisms, fresh-water and salt-water jellyfish and weevers. They have not been discussed by the Committee because they are either very rare or because the effects they cause are not severe.

Question 2

What is the opinion of the Health Council about the system of standards and microbiological standards currently in place (pursuant to the Swimming Pools (Hygiene & Safety) Act) for the prevention of risks of infection as a result of bathing in surface water? In concrete terms, the question here is whether, on the basis of data about the presence of certain indicator organisms such as faecal coliforms, sufficiently *reliable assessments can be made of the risk of contracting infections caused by pathogenic organisms.*

Answer

For various reasons, the current standards do not provide adequate protection for exposure to concentrations corresponding to the current standards for faecal contamination.

The current system, which focuses exclusively on faecal contamination, provides no protection against pathogens of non-faecal origin. The Committee believes that some catching up needs to be done for cyanobacteria given the levels in the Netherlands and the associated risk. Monitoring of the number of cyanobacteria and the toxin concentrations in Dutch waters should be carried out as a matter of urgency. Furthermore, the inclusion of these pathogens in the Swimming Pools (Hygiene & Safety) Act would seem to be a natural step.

Various studies, which were discussed in chapter 3, have found health problems at concentrations of faecal contamination below the current standards. The Committee has drafted a proposal for recommended exposure limits for fresh and salt water. The indicators to be used for these values — intestinal enterococci and *E. coli* — correspond more closely to the incidence of disease than those used for the current standards.

Implementation of the standards could also be improved. The Committee believes that the representativity and reproducibility of the current method of sampling (discussed in 7.1) are inadequate. For example, at present, only one sample is taken per site in order to establish the level of contamination. A repeat sample is taken where there is non-compliance with the standard. The Committee considers the representativity and reproducibility of this procedure to be inadequate as a basis for reliable risk assessment. Research on variation in indicator concentration for faecal contamination will be required to show which sampling strategy is optimal. For the time being, the Committee considers a composite sample taken from ten sites to be a minimum requirement. In addition, it recommends adjusting the frequency of measurements in light of the anticipated risk associated with, for example, large numbers of visitors, sources, previous non-compliance with the standards and local conditions. To prevent disease, action must be taken immediately after non-compliance has been detected. Further investigations are required after non-compliance of this kind has been found in order to trace the sources. This will show whether the contamination is still taking place and whether the measures should remain in place.

In general, the Committee believes that the current policy concentrates too much on repression. It has drawn up proposals in chapters 6 and 7 for measures which focus more on the prevention of risk.

Question 3

Which criteria could be followed, when introducing a ban on bathing, alongside or instead of existing criteria (statutory standards)? Would you also consider it to be sensible to develop criteria which could be used as a basis for advising against bathing or issuing a recommendation not to bathe?

Answer

The control measures in the five links of the safety chain described in chapter 6 constitute a comprehensive system based on more than just prohibitions. The decision about whether to designate a water as bathing water using a risk profile, about whether to including that bathing site on a map of the province and, finally, the drafting of a control plan are regarded by the Committee as the most important links in this chain. This emphasis on proaction and prevention is appropriate for the, generally speaking, relatively minor nature of the effects of microbial contamination of bathing water.

The Committee is of the opinion that bans should be introduced only in very exceptional circumstances but that they should also be enforced. This is bound up, in its view, with the nature of the effect of the pathogen concerned. As the Committee pointed out in chapter 7, it believes that bans are justified in the following circumstances: botulism, severe cases of leptospirosis, surface blooms of cyanobacteria and in the presence of thermally-polluted bathing water. In less severe situations, such as non-compliance with the recommended exposure limit for indicators of faecal pollution, a warning sign advising against bathing is adequate.

Question 4

Would it be desirable to check other risks, for example of a chemical nature, in addition to microbiological parameters, in order to protect bathers' health? If so, which parameters should be considered in this respect?

Answer

The Committee proposes a system in which the initial step consists of drawing up a risk profile for a site before that water can be designated as a bathing water. Part of this risk profile consists of a survey of risk-bearing activities and situations, such as the presence of shipping, currents, physical agents (for example metal and glass) and chemical pollution. If, for example, there is chemical pollution, an estimate of the risk should be made. Initially, it is the responsibility of the local supervisory authority to take action when a risk is suspected.

Question 5

How, in addition to the arrangements already in place, would you inform the public about the risks of bathing in surface water?

Answer

The Committee has (in 6.3) looked at the types of information which it believes should be provided to the public. One of its conclusions was that information activities should be limited to situations in which preventing people from bathing is an urgent necessity. In addition, a map with suitable bathing water sites of the kind proposed by the Committee constitutes a proactive information approach.

Question 6

Are specific recommendations required for vulnerable groups, such as people with an impaired immune system, with respect to bathing or recreation in surface waters?

Answer

People belong to a high-risk group if their exposure or sensitivity to pathogens present in recreational waters is higher than for the average recreationist. High-risk groups as a result of more than average exposure are: divers, surfers and small children. The Committee would wish to point out that the current system focuses on bathing water and not on waters where people surf or dive. In general, in terms of sensitivity, the people in high-risk groups are: very young or very elderly people, people suffering from one or more diseases, overweight or underweight people or people with compromised immune systems. The Committee sees no reason to designate very young children as high-risk group on the grounds of increased sensitivity. For those who are particularly sensitive and therefore belong to a high-risk group, the Committee believes that it is primarily the responsibility of the attending physician to provide information on this subject and where appropriate to discuss the advisability of bathing. In annex

D, the Committee has provided a more detailed review of the high-risk groups for the profession.

Question 7

In your view, what should be the primary focus of future research into the risks of infection as a result of bathing?

Answer

The establishment of a risk profile plays a central role in the control measures. Given the lack of experience in drafting and evaluating risk profiles, further research in this area is desirable. This is particularly true for the relationship between sources of faecal contamination and the microbial quality of bathing water.

In order to improve our understanding of the risks of pathogens — and particularly of cyanobacteria — further research into the effects of exposure is desirable. The Committee believes that the first step in this direction is to improve registration procedures.

Faecal contamination

The Committee believes that research is required into the fluctuations in space and time in the concentration of indicators of faecal contamination. The results of this research will indicate the best sampling strategy for proper action. In this respect, it is also desirable to support research which will reduce the time needed to analyse indicators. At present, it is already possible to determine concentrations of *E. coli* within 4 hours. In the future, it may be possible to measure concentrations of indicators on a continuous basis. This would be desirable both for the purposes of understanding the risks and of taking adequate action.

Although the Committee believes that the recommended exposure limits for faecal contamination it proposed are adequate, it believes that further development would also benefit from research into the main individual pathogens. It is possible that these are viruses, *Campylobacter* and *Cryptosporidium.* Bacteriophages may be a good indicator for viruses, and recommended exposure limits for individual pathogens may act as supplements to, or replacements of, the indicators proposed in this advisory report.

Cyanobacteria

The Committee believes that cyanobacteria constitute the main threat to bathers. In addition to the measurement of toxins in bathing water, more research is required into the effects of these toxins. In addition to improvements in the registration of symptoms, targeted research into the effects is also desirable. Since there are hardly any methods available at present for reducing cyanobacteria levels, the development of such methods requires more attention. Here, research into the environmental conditions which have an effect on the toxicity of cyanobacteria is also important.

Literature

Ack97 Ackman D, Marks S, Mack P *et al*. Swimming-associated haemorrhagic colitis due to escherichia coli O157: H7 infection: evidence of prolonged contamination of a fresh water lake. Epidemiol Infect 1997; 119: 1-8.

All94 Allerberger F, Wotzer G, Dierich MP, Moritz C, Fritsch P, Haas W. Auftreten von Badedermatitis in Tirol. Immun Infekt 1994; 22: 30-2.

Asp95 van Asperen IA, de Rover CM, Colle C, Schijven JF, Bambang Oetomo S, Schellekens JFP, van Leeuwen WJ, Havelaar AH, Kromhout D, Sprenger MJW (1995). Een zwemwatergerelateerde epidemie van otitis externa in de zomer van 1994. Rapport 21466600, RIVM, Bilthoven.

Asp98 van Asperen IA, Medema G, Borgdorff MW, *et al*. Risk of gastroenteritis among triathletes in relation to faecal pollution of fresh waters. Inter J Epidemiology 1998; 27: 309-15.

Aqu00 AquaSense. Toxische cyanobacteriën en cynotoxines in Nederlandse recreatiewateren in 1998. Rapportnummer: 1103. (2000)

Bid84 Biddick CJ, Rogers LH, Brown TJ, 1984. Viability of pathogenic and nonpathogenic free-living amoebae in long-term storage at a range of temperatures. Appl Environ Microbiol 48; 859-60.

Bla91 Blankespoor HD, Reimink RL. The control of swimmer’s itch in Michigan: past, present and future. Michigan academ 1991; 24: 7-23.

Bon58 Bonsel J, Stam AB, Stam-Mielziner SJ, Thiel PH van. Schistosoma dermatitis in The Hague. Trop Geogr Med 1958; 10: 239-44.

Car85 Carmichale WW, Jones CLA, Mahmood Na, *et al*. Algal toxins and waterbvased diseases. CRC Crit Rev Environ Control 1985; 15(3): 275-303.

Cer82 Cerva L, Kassprazak W, Mazur T, 1982. Naegleria fowleri in cooling waters of power plants. J Hyg Epidemiol Microbiol Immunol 26; 152-161;

Cha98 Chamot E, Toscani L, Rougemont A. Public health importance and risk factors for cercarial dermatitis associated with swimming in Lake Leman at Geneva, Switzerland. Epidemiol Infect 1998;120:305-14.

Coh53 Cohen SG, Reif CB. Cutaneous sensitization to blue-green algae. J Allergy 1953; 24: 452-7.

Dil60 Dillenberg HO, Dehnel MK. Toxic waterbloom in Saskatchewan, 1959. Can Med Assoc J 1960; 83: 1151-4.

Div81 Dive DG, Leclerc H, DeJonckheere JF, *et al*. Isolation of Naegleria fowleri from the cooling pond of an electric power plant in France. Ann. Microbiol 1981; 132: 97-105.

Don88 Donk E van, Collé C. Cercariën-dermatitis, een mogelijke complicatie bij toepassing van actief biologisch beheer in zwemwateren. H2O 1988; 21: 696-9

Duy00 Duy TN, Lam PK, Shaw GR, *et al*. Toxicology and risk assessment of freshwater cyanobacterial (blue-green alga) toxins in water. Rev Environ Contam Toxicol 2000; 163: 113-85.

Eu76 Proposal for revision of Directive 76/160/EEC. OJ N C 138, 17.5.1993.

EPA86 Ambient water criteria for water (EPA 440/5-84-002), EPA, Waschington DC, US 2000 Environmanetal Protection Agency.

EPA00 Implementation guidance for ambient water quality criteria for bacteria — 1986. (EPA 823-D-00-001), Waschington DC, US 2000 Environmanetal Protection Agency.

Fal88 Falconer IR, Smith JV, Fackson ARB, *et al*. Oral toxicity of a bloom of the cyanobacterium Microcystis aeruginosa administered to mice over periods up to 1 year. Jouranl of Toxicology and Envirunmental Helath 1988; 24: 291-305.

Fal91 Falconer IR. Tumour promotion and liver injury caused by oral consumption of cyanobacteria. Environmental Tocicology and Water Quality 1991; 6: 177-84.

Fal94 Falconer EI. Health problems from exposure to cyanobacteria and proposed safety guidelines for drinking and recreational water. In: Codd GA, Fefferies TM, Keevil CW, Potter E (eds) Detection Methods for Cyanobacterial Toxins. Roual Society of Chemistry, London, 1994b; 3-10.

Faw94 Fawell JK, James CP and James HA. Toxins from Blue-Green Algae; Toxicological Assessment of Microcysin-LR and a Method for its Determination in Water, Water Research Centre, Medmenham, UK 1994; 1-46.

Faw99 Fawell JK, Mitchell RE, Everet DJ, *et al*. The toxicity of cyanobacterial toxins in the mouse; I microcystin-LR. Human & Experimental Toxicology 1999; 18: 162-7.

Fle96 Fleisher JM, Kay D, Salmon RL, *et al* Marine waters contaminated with domestic sewage: Nonenteric illnesses associated with bather exposure in the United Kingdom. Am J Public Health 1996; 86: 1228-34.

Fra78 Francis G. Poisonous Australian lake. Nature 1878; 18: 11-2.

Gel99 Geldreich EE. Pseudomonas. In: AWWA Manual Waterborne Pathogens, AWWA, Denver, USA 1999; 103-105.

Gen96 Gentile L de, Picot H, Bourdeau P, Bardet R, Kerjan A, Piriou M, Guennic A Le, Bayssade-Dufour C, Chabasse D, Mott KE. La dermatite cercarienne en Europe: un problème de santé publique nouveau? Bull WHO 1996; 74: 159-63.

GR95 Gezondheidsraad: Commissie Risicomaten en risicobeoordeling. Niet alle risico’s zijn gelijk. Den Haag. Gezondheidsraad. 1995; nr 1995/06.

GR01 Gezondheidsraad: Commissie Gexondheidsrisico's van contactlenzen. Gezondheidsrisico's van contactlenzen. Den Haag: Gezondhiedsraad, 2001; publicatie nr 2001/20.

Hin75 Hindman SH, Favero MS, Carson LA, *et al*. Pyrogenic reactions during haemodialysis caused by extramural endotoxin. Lancet 1975; 2: 732-4.

Hoa75 Hoadley AW, Knight DE. External otitis among swimmers and nonswimmers. Arch. Environ. Health 1975; 30: 445-448.

Hui90 Huizinga HW, McLaughlin GL, 1990. Thermal ecology of Naegleria fowleri from a power plant cooling reservoir. Appl Environ Microbiol 56; 2200-2205.

Joc98 Jochimsen EM, Carmichael WW, An J, *et al*. Liver failure and death after exposure to microcystins at a haemodialysis center in Brazil. New Engl J med 1998; 338(13): 873-878.

Joo64 Joosse J. Dorsal bodies and dorsal neurosecretory cells of the cerebral ganglia of Lymnaea stagnalis L. Arch Néerl Zool 1964; 16: 1-103.

Jon77 De Jonckheere JF, Van de Voorde H, 1977. The distribution of Naegleria fowleri in man-made thermal waters. Am J Trop Med Hyg 26; 10-15.

Kay94 Kay D, Fleisher JM, Salmon RL, *et al*. Predicting likelihood of gastroenteritis from sea bathing: results from randomised exposure. Lancet 1994; 344: 905-9.

Kir81 Kirpenko YA, Sirenko LA, Kirpenko, NI. Some aspects concerning remote after-effects of blue-green algal toxin impact on warm-blooded animals. In The Water Environment, Algal Toxins and Health ed. Carmichael WW. New York: Plenum Press 1981; 257-69.

Kol89 Kolarova L, Gottwaldova V, Cechova D, Sevcova M. The occurrence of cercarial dermatitis in Central Bohemia. Zentralbl Hyg Umweltmed 1989; 189: 1-13.

Koo85 Koops FBJ. Menspathogene organismen in Nederlandse koeltorens. Rapport 5242 – 85MOB, KEMA, Arnhem 1985.

Lee00 Leenen EJTM. Gezondheidsklachten in verband met recreatie in oppervlaktewater in de zomer van 1999. Inf Bull 2000; 11: 133-5.

Lei55 Leigh WH. The morphology of Gigantobilharzia huttoni (Leigh, 1953) an avian schistosome with marine dermatitis-producing larvae. J Parasitol 1955; 41: 262-9.

Lya77 Lyaruu DM, Bij de Vaate A, Gaasenbeek CPH, Over HJ, Sluiters JF. Transmission ecology of schistosome dermatitis in The Netherlands. Trop Geogr Med 1977; 29: 207.

Mat92 Mates A. The significance of testing for Pseudomonas aeruginosa in recreational seawater beaches. Microbios 1992; 71: 89-93.

Mar97 Martinez AJ, Visvesvara GS. Free-living, amphizoic and opportunistic amebas. Brain Pathol 1997, 7; 583-598.

Mit79 Mittal A, Agarwal M and Schivpuri D. Respiratory allergy to algae: clinical aspects. Ann Allergy 1979; 42: 253-6.

Mug00 Mugglestone MA, Stutt ED and Rushton L. A review of the health effects of sea bathing water. UK, Institute for Environment and Health (IEH), 2000.

Mul93 Muller V, Kimmig P, Frank W. Die Wirkung von Praziquantel auf Trichobilharzia (Digenea, Schistosomatidae), einen Verursacher von Badedermatitiden beim Menschen. Appl Parasitol 1993; 34: 187-201.

Nis92 Nishiwaki-Matsushima R, Ohta T, Mishiwaki S, et al. Liver cancer promoted by the cyanobacterial cyclic peptide toxin microcystin LR. Journal of Cancer Research and Clinical Oncology 1992; 118: 420-4.

Oli49 Olivier L. The penetration of dermatitis-producing schistosome cercariae. Am J Hyg 1949; 49: 134-9.

Pil97 Pilotto LS, Douglas RM, Burch MD, *et al*. Health effects of exposure to cyanobacteria (blue-green algae) during recreational water-related activities. Aust N Z J Public Health 1997; 21(6): 562-6.

Prü98 Prüss A. Review of epidemiological studies on health effects from exposure to recreational water. Inter J Epidemiolog 1998; 27: 1-9.

Rei95 Reimink RL, Goede JA de, Blankespoor HD. Efficacy of praziquantel in natural populations of mallards infected with avian schistosomes. J Parasitol 1995; 81: 1027-9.

Sal53 Salomé BZ. Het vóórkomen van schistosoma-dermatitis in Nederland. Ned Tijdschr Geneeskd 1953; 97: 3228-32.

Slu80 Sluiters JF, Brussaard-Wüst CCM, Meuleman EA. The relationship between miracidial dose, production of cercariae, and the reproductive activity of the host in the combination Trichobilharzia ocellata and Lymnaea stagnalis. Z Parasitenkd 1980; 63: 13-26.

Slu83a Sluiters JF. Observations on the identity of the avian schistosome Trichobilharzia ocellata (La Valette, 1855) Brumpt, 1931. Acta Leidensia 1983a; 51: 53-60.

Slu83b Sluiters JF, 1983. Parasite-host relationship of the avian schistosome Trichobilharzia ocellata and the hermaphrodite gastropod Lymnaea stagnalis. Thesis, Vrije Universiteit Amsterdam, ICG Printing, Dordrecht.

Spr85 Springer GL, Shapiro ED. Fresh water swimming ask risk factor for otitis externa: a case control study. Arch Environ Health 1985; 40: 202-206.

TK89 Omgaan met risico's; de risicobenadering in het milieubeheid. Bijlage bij het Nationaal Milieubeleidsplan. Handelingen Tweede Kamer, vergaderjaar 1988-1989, nr 21137 -5. Den Haag: SDU, 1989.

Tur90 Turner PC, Gammie AJ, Hollinrake K, *et al*. Pneumonia associated with contact with cyanobacteria. Britisch Medical Journal 1990; 300: 1440-1.

Vis99 Visvesvara GS. Naegleria fowleri. AWWA Manual Waterborne Pathogens, AWWA, Denver, USA 1999.

Wit95 de Wit MAS, van Asperen IA, Colle C, *et al*. Prospectieve cohortstudie naar het optreden van gezondheidsklachten na deelname aan een zwemwedstrijd in oppervlaktewater in de zomer van 1994. Rapport 289202008, RIVM, Bilthoven, 1995.

WHO98 Guidelines for safe recreational-water environments: Coastal and fresh-waters (draft for consultation). Geneva, Switzerland, World Health Organization, 1998.

WHO00 I Chorus and J Bartram (ed). Toxic cyanobacteria in water; a guide to their public health consequences, monitoring and management. World Health Organization, Geneva.

Yos87 Yoshpe-Purer Y, Golderman S. Occurrence of Staphylococcus aureus and Pseudomonas aeruginosa in Israeli coastal water. Appl Environ Microbiol 1987; 52: 1138-41.

Yu89 Yu SZ. Drinking water and primary liver cancer. In: ZY Tang, MC Wu and SS Xia(eds) Primary Liver Cancer. China Academic Publishers, New York 1989; 30-7.

Yu95 YU SZ. Primary prevention of hepatocellular carcinoma. J Gastroenterol Hepatol 1995; 10(6): 674-82.

A Request for advise

B The Committee

C Control measures for Trichobilharzia ocellata

D High-risk groups

Annexes

Annex **A**

Request for advise

On 29 January 1999, the Minister of Housing, Spatial Planning and the Environment asked the Health Council, through the Minister of Health, Welfare and Sport, for an advisory report about the microbiological quality of bathing water (letter no. DWL/99132424). The Minister wrote:

Through you, I request the Health Council to advise me about the standards for the quality of surface water which has been designated as bathing water.

The basic assumptions behind this request for an advisory report are: The consideration that, for the protection of the environment and public health, and with a view to recreational interests, it is necessary for the quality of bathing water in the Netherlands to meet the harmonised standards and criteria set for that purpose on the community level. The prevailing EU directive relating to the quality of bathing water (76/160/EEC) will be revised next year to take into account ongoing technical developments and understanding in the area of the protection of the health of swimmers and bathers. Essential components of this revision are the system of standards for bathing water quality and the way in which bathers are provided with the most recent information relating to water quality or the risks of bathing in surface water.

The EU bathing water directive has been implemented in the Pollution of Surface Water Act: the Surface Water Quality Objectives and Measurements Decree (BKMO) and in the Swimming Pools (Hygiene & Safety) Act. Pursuant to the Surface Water Quality Objectives and Measurements Decree, there are requirements for water quality control (cleanup objectives), whereas, pursuant to the Swimming Pools (Hygiene & Safety) Act, there are requirements for bathing water in the interests of bather hygiene and safety and the associated obligation for the provincial executive, in certain cases, to introduce a bathing ban or close a swimming pool. Implementation in Dutch legislation is based on the imperative standards of the EU directive and, with the exception of the faecal streptococci parameter, does not take into account the target figures adopted by the EU, which, if these values are complied with, mean that the bathing water can be deemed ‘of excellent quality’. Other relevant legislation in the field of bathing in surface water is the Control of Infectious Diseases and Investigation of Causes of Disease Act (WBIOZ). A protocol has been drawn up in consultation between the provincial authorities and the Public Health Inspectorate for the co-ordination required for the purposes of closing bathing facilities or introducing a bathing ban. This protocol is important for the purposes of the early identification of problems with water quality: on the one hand, attention can be drawn to these problems by reports of symptoms in bathers by Municipal Health Services and on the other hand the bimonthly analysis results for water quality which are submitted to the provincial authorities may constitute a reason to watch out for health risks associated with bathing. In addition to the degree of water pollution, another important factor in terms of good bathing water quality is the quality of the surroundings in the vicinity of the bathing zone. Sewage overflows, bird colonies, run-off of manure and other factors are often the cause of inadequate microbiological water quality. Analyses of the quality of the bathing water are generally conducted by the relevant water authority; the Institute for Inland Water Management and Wastewater Treatment (RIZA) produces a report annually about the quality of bathing water in the member states.

An important part of the revision of the European directive will be the regulation of the way in which the public can gain access to the latest data about bathing water quality or possible health risks associated with bathing in the surface water in question. At present, the provincial authorities in the Netherlands supply the information on the teletext system. This information consists of a list of the sites with inadequate bathing water quality where a bathing ban is in place or where people are advised not to bathe and also of general information, for example about the potential hazards of blue-green algae toxins or of bacterial contamination such as Pseudomonas aeruginosa (otitis externa) etc. In addition, the provincial authorities distribute bathing water folders through, for example, tourist information offices and information is also supplied on the radio and the newspapers where appropriate.

The National Institute of Public Health and Environmental Protection (RIVM) has regularly produced publications about the health risks of bathing in surface water. The greatest risks are mainly associated with lengthy warm periods, as in 1994 and 1995. Familiar publications in this respect are those about cyanobacteria, Pseudomonas aeruginosa and other possible pathogens such as viruses, parasitic protozoa, schistosomes etc. Standards for the risk of infection as a result of bathing are based on a maximum permissible risk of 10-4 per person per year. In practice, it has been proved to be virtually impossible to use this risk limit as a basis for the development of practical standards for indicator organisms such as faecal coliforms and enterococci (faecal streptococci). The position that the current system provides standards rather than adequate protection was emphasised again by the results of an RIVM study from 1991 (report no. 968902001) in which the symptoms (gastro-enteritis) of swimmers who had participated in a triathlon were compared to the symptoms of a comparable group of ‘run-bike-runners’. Although the athletes swam in water which met the standards of the Swimming Pools (Hygiene & Safety) Act, the numbers of symptoms in the swimmers group were significantly higher.

Given the above and with a view to the consultations which were recently initiated on the European level with respect to the amendment of the EU bathing water directive, and for the purposes of establishing a Dutch position in this matter, I hereby request you to advise me on the following questions:

What is the opinion of the Health Council about the system of standards and microbiological standards currently in place (pursuant to the Swimming Pools (Hygiene & Safety) Act) for the prevention of risks of infection as a result of bathing in surface water? In concrete terms, the question here is whether, on the basis of data about the presence of certain indicator organisms such as faecal coliforms, sufficiently reliable assessments can be made of the risk of contracting infections caused by pathogenic organisms

Which pathogens play a role in the risk associated with bathing in surface water and how can the various factors be mapped out in greater detail?

Which criteria could be followed, when introducing a ban on bathing, alongside or instead of existing criteria (statutory standards) and would you also consider it to be sensible to develop a separate set of criteria which could be used as a basis for advising against bathing or issuing a recommendation not to bathe

Would it be desirable to check other risks, for example of a chemical nature, in addition to microbiological parameters in order to protect bathers' health and, if so, which parameters should be considered in this respect

How, in addition to the arrangements already in place, would you inform the public about the possible risks of bathing in surface water

In your view, what should be the primary focus of future research into the risks of infection as a result of bathing

Are specific recommendations required for vulnerable groups, such as individuals with an impaired immune system, with respect to bathing or recreation in surface waters?

I ask you to urge the Health Council to respond to this request for an advisory report as quickly as possible in the light of the consultations which started recently relating to the revision of the European directive on bathing water quality. For information purposes, I am sending a copy of this letter to the President of the Health Council.

The Minister of Housing,
Spatial Planning and the Environment
signed Jan Pronk

Annex **B**

The Committee

- A Wijbenga, *chairman*
  environmental toxicologist; Province of South Holland, The Hague
- J van Dissel
  professor of infectious diseases; Leiden University Medical Centre, Leiden
- BJAM Haring, *consultant*
  Ministry of Housing, Spatial Planning and the Environment; The Hague
- J Huisman
  emeritus professor of epidemiology and infectious disease control, Rotterdam
- EJTM Leenen
  microbiologist; National Institute of Public Health and Environmental Protection (RIVM), Bilthoven
- GJ Medema
  microbiologist; KIWA Water Research, Nieuwegein
- LR Mur
  professor of microbiology; University of Amsterdam, Amsterdam
- H Ruiter
  environmental scientist Institute for Inland Water Management and Wastewater Treatment (RIZA), Lelystad
- JF Sluiters
  parasitologist; Erasmus University Medical Centre, Rotterdam
- F Woudenberg
  psychologist; Rotterdam City Health Service, Rotterdam

- JH van Wijnen
  medical environmental scientist; Amsterdam City Health Service, Amsterdam
- JW Dogger, *secretary*
  Health Council; The Hague

Guest experts

- RA Hartskeerl
  microbiologist; Royal Tropical Institute, Amsterdam
- SHW Notermans
  microbiologist; TNO Nutrition and Food Research Institute, Zeist
- P Speelman
  professor of general internal medicine; Academic Medical Centre, Amsterdam
- VJ Feron
  emeritus professor of biological toxicology, Zeist

Secretarial support: M Javanmardi.
Layout: J van Kan, M Javanmardi.

Annex **C**

Control measures for Trichobilharzia ocellata

existing bathing water	*designation*	*actions in the context of the safety chain*
no pond snails	bathing water with no risk of swimmer's itch	none
pond snails present no swimmer's itch in past	bathing water with low risk of swimmer's itch	prevention: check for presence of schistosomes (for example, 3x10 pond snails in spring and summer). When found; repression: collect snails
pond snails present swimmer's itch in past	bathing water with risk of swimmer's itch	prevention*: (repeat) check on presence of schistosomes, for example during the bathing season (3x10 pond snails/14 days), when found; repression: collect snails.
new bathing water	*designation*	*actions in the context of the safety chain*
no pond snails	bathing water with no risk of swimmer's itch	prevention: annual survey of snail population
pond snails present no swimmer's itch	bathing water with low risk of swimmer's itch	prevention: check development of snail population1 (repeat) check for presence of schistosomes; when found; repression: collect snails.
pond snails present swimmer's itch present	not bathing water, unless control measures taken for snails (collection) and no more cases	repression: check on presence of schistosomes (here, 3x10 snails may not be enough). Collect pond snails. If cases persist: not bathing water. Depending on repressive action, review admission again after 1 year.

NB As a proactive measure, a survey of the snail population will be conducted. The presence of a bird colony will, in the proactive stage, exclude the possibility of the designation 'bathing water'.

* Consider, as a preventive measure, collecting pond snails twice a year.

Annex **D**

High-risk groups

Individuals can never be fully protected against infectious disease after exposure to surface water. Two questions are relevant when defining vulnerable groups: Is there an increased risk of contracting an infectious disease after exposure to surface water? And, if an infectious disease is contracted, is there an increased risk of a serious health problem?

People belong to a high-risk group if their exposure or sensitivity to pathogens present in recreational waters is higher than for the average recreationist. High-risk groups as a result of more than average exposure are: divers and surfers, who spend more recreational time in water, and young children, who ingest water. These groups also include older people with swallowing disorders. Above-average sensitivity to pathogens present in recreational water occurs if there is a problem with immune mechanisms such as the killing of bacteria by stomach acid or intestinal peristalsis. This may be caused by the use of medication or a disease (see Table 3).

The absence of immunoglobulin (Ig)A produced and secreted locally in the intestinal mucous membrane also results in an increased susceptibility to infection. In all these cases, the number of micro-organisms that has to be ingested before contracting an infectious disease is significantly less than normal. Control measures based on a generally prevailing standard will not be adequate for these risk groups.

Table 3 Immune disorder and risk of infection after exposure to pathogens in recreational water

immune disorder	Example	infection by
Skin defect (particularly in diabetes mellitus or vascular affliction)	Interdigital lesions, minor wounds or ulcers, dermatitis external auditory canal, peritoneal dialysis catheter, 'port-a-cath'	faecal flora, Pseudomonas *spp* Aeromonas hydrophilia vibrio *spp* Pleisiomonas *spp* Leptospira *spp*
Disordered cough or swallowing reflex	Opiates, alcohol, neurological diseases	aspiration pneumonia: flora listed above in 'near drowning' also: Pseudallescheria boydii Aspergillus *spp*
Anacidity	Proton pump inhibitors, H2 blockers, Atrophic gastritis, condition after stomach operation	Salmonella *spp* Campylobacter *spp* Aeromonas hydrophilia E. Coli (EHEC)
Disturbed peristalsis	Opiates, small intestine diverticula, active Crohn's disease/colitis ulcerosa, scleroderma	Campylobacter *spp* Salmonella*spp* E. Coli (EHEC)
Immunoglobulin deficit	a- or hypo-gammaglobulinaemia, secretory IgA deficiency	Campylobacter *spp* Giardia lamblia Salmonella*spp*
Phagocyte defect	Granulocytopenia, chronic granulomatous diseases, glucocorticosteroids	Salmonella *spp* Pseudomonas *spp* Aeromonas hydrophilia
T-lymphocyte defect	Congenital (SCID), HIV/AIDS, Hodgkin's disease, malignant lymphoma, Immunosuppressants or glucocorticosteroids	Salmonella *spp* Campylobacter fetus Cryptosporidium Listeria monocytogenes mycobacteria
Locus minoris resistentiae	Vascular prosthesis (aorta bifurcation prosthesis), heart valve, hip or knee prosthesis wearers of contact lenses	Salmonella *spp* Pseudomonas *spp* Acanthamoeba *spp*

If someone is infected after exposure to recreational water, there may be complicating circumstances which affect recovery. For example, the risk of dehydration as a result of diarrhoea and vomiting is high in very young, pregnant and very elderly patients, and people with diabetes mellitus can suffer from metabolic disruption. Bacterial infections in patients with impaired host immunity (for example, granulocytopaenia) can have a rapid and violent course. In people with a vascular or articular prosthesis, it is necessary to prevent micro-organisms entering the blood from the intestines and bonding to the prosthesis material.

In most cases, the attending doctor will have made a note in the file that a patient belongs to a specific high-risk group. When people are particularly sensitive and therefore belong to a high-risk group, it is primarily the responsibility of the attending physician to provide information about the possible risks of bathing in recreational waters.

Finally, water recreationists themselves make a major contribution to the contamination of water with pathogens. This makes control of the recreational burden desirable. People with gastrointestinal complaints for skin infections should be dissuaded from engaging in water recreation. Doctors should also be aware of the importance of their reporting role: in the case of most pathogens, the surface water is only investigated (or recommendations not to bathe are only issued) when there are *indications* that there is a problem.