

International Report: Health-related water microbiology

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Abstract This report summarises the reports on health-related water microbiology of a number of countries. Although this is supposed to be an international report, only some 18 countries have submitted reports, all but five of which were European. There were no reports submitted from the Americas and few from African or Asian countries. These omissions are particularly notable when considering the fact that the largest burden of waterborne disease falls on the populations of these continents.

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Introduction

Health-related water microbiology is at the heart of the water industry as it concerns itself with the very safety of water production. Health-related water microbiology concerns a number of key issues in regard to the production of microbiologically safe drinking water:

1. the effectiveness of water treatment technologies at removing potential microbial pathogens;
2. methods of detection of microbial pathogens and indicator organisms in drinking water;
3. the prevalence of pathogens and indicator organisms in water supplies;
4. the epidemiology of infectious disease in human population that may be related to drinking water.

The national reports below illustrate both commonality and diversity in issues of health-related water microbiology. The commonality amongst nations is seen best in the area of treatment processes. All countries that submitted reports treat the largest proportion of their water supplies by the multiple barrier approach. All rely heavily on total coliform and *E. coli* as indicators of acceptable water quality. Most also rely on appropriate international standards in informing microbiological methods for the examination of water. Also, in all countries, the responsibility for surveillance of infectious disease likely to be associated drinking water rests with local and national health authorities.

The differences between countries is seen in the attitude to direct monitoring of pathogens, particularly for *Cryptosporidium*, and in the reported prevalence of outbreaks and sporadic infectious disease that could be linked to drinking water. These two issues will be discussed in more detail.

Direct monitoring of water for pathogens

There are widely differing approaches to monitoring of water supplies for the presence of pathogens. These differing approaches reflect considerable debate amongst water microbiologists about the merits of monitoring water supplies for pathogens. With the exception of cryptosporidiosis discussed below, no country advocates monitoring of all water supplies for potential pathogens, but many undertake some degree of sampling. The arguments in favour of moving towards direct pathogen detection include the fact that many of the emerging waterborne pathogens, such as protozoa and viruses, have been implicated in outbreaks of waterborne disease in the absence of classical indicator organisms. Furthermore,

although several studies have indicated a correlation between *E. coli* and enterococcal counts in drinking water and risk to health, no such correlation has been demonstrated for other indicators such as total coliforms or heterotrophic plate count. Data on counts of pathogens in drinking water should give better estimates of risk.

On the other hand, many of the available technologies for pathogen detection in drinking water are currently insensitive, inaccurate, or costly and time consuming to perform routinely. The wide range of potential pathogens that could be tested for to give a comprehensive assessment of safety would require the performance of many different analyses, further increasing cost and resource requirements. Nevertheless, current methods still have a role in outbreak investigation, special surveys and in performing exposure assessments during formal risk assessments. Furthermore, the situation is changing very dramatically as new technologies, such as DNA chip technology, are developed. Such technology may allow the widespread use of pathogen detection in coming years. However, it is likely that the cost of new technology will limit its use to the more affluent countries.

One pathogen that is now routinely tested for in a number of countries is *Cryptosporidium*. Several of the national reports mention either current testing for this organism in water, or express the intention of testing in the near future. The report from the UK describes the only experience of continuous large volume sampling for a pathogen in treated drinking water. It is notable that many of the water supplies have *Cryptosporidium* detected, albeit in small numbers. On the other hand, there have been few exceedences of the statutory limit and on no occasion was this followed by an increase of cases occurring in people in the community consuming that water. The value of continuous monitoring of water supplies for *Cryptosporidium* is still hotly debated.

Reported prevalence of human infections

Perhaps the biggest discrepancy between nations in the area of health-related water microbiology is the amount of waterborne disease and outbreaks reported. One of the most obvious drivers of political interest in water safety in a country is the reported presence of outbreaks of waterborne disease. The occurrence of outbreaks also frequently drives a country's research priorities as they usually attract significant media interest.

It is difficult to blame this discrepancy on differences in the safety of water supplies as most countries have very similar standards of water quality and water treatment. The most likely explanation for this difference comes from the major differences in a nation's ability to detect outbreaks of waterborne disease. Even within the European Union, some member states simply do not have surveillance systems in place with the capability of detecting outbreaks of waterborne disease. Even in member states with surveillance systems it is probable that only a proportion of outbreaks are detected. As yet there is no surveillance system able to detect sporadic waterborne disease. An adequate surveillance system requires a medical system to which people suffering from gastrointestinal symptoms will present and that adequately investigates patients with diarrhoeal disease. The adequate investigation of diarrhoeal disease requires the availability and use of diagnostic laboratories able to examine stool samples for the presence of enteric pathogens. These laboratories must also report to local and national bodies that must collate and regularly analyse their data. Without such surveillance systems being developed in all countries, direct country-to-country comparison of waterborne disease is fraught with difficulty.

The problems discussed in the previous paragraph highlight a significant problem in health-related microbiology, the lack of connection at the international level and in many individual countries between the water industry and public health communities. If the health and safety of the consumer is the priority in water systems management, why are

there so few times when public health specialists and water industry experts share the same meetings?

One important issue that has not been dealt with in these reports is the problem of health effects in those people that do not have the benefit of mains supplies. Even in otherwise developed nations, there is still a proportion of the population whose water comes from small or private sources. The quality of these supplies is often quite poor and, what evidence is available does suggest that consumers taking their drinking water from these sources are at increased risk of illness. Despite this increased risk, there has still been very little interest in most countries in researching or addressing the problems associated with small supplies.

National summaries

Australia

Australia follows National Health and Medical Research Council and WHO standards for water quality. Although national legislation may not be fully up-to-date with these standards the Australian system of common law tends to ensure that practice within water utilities does follow best practice. With the exception of Sydney, there is currently no requirement to monitor water for *Cryptosporidium*. In Sydney there is mandatory monitoring of 20 litre samples each day at a number of sites. For microbial indicators, there is a trend to de-emphasise total coliforms and rely on *E. coli* as the primary indicator. Another trend is the targeting of effort on system management rather than on setting guidelines. Water treatment systems are generally of a high standard and reflect state-of-the-art engineering technologies. There have been no outbreaks associated with large municipal supplies, though some have been identified in small communities. A randomised blinded controlled study has recently been completed which demonstrated that drinking water did not contribute to the burden of diarrhoeal disease in Melbourne. In part this low incidence of outbreaks and systematic disease may reflect the low population density in Australia.

Belgium

Usually only the microbial indicators necessitated by the recent European drinking water directive are monitored in Belgium, though *Legionella* in showers at swimming pools and *Cryptosporidium* sp., *Giardia* spp. and algae are monitored in surface waters and also ground water under the influence of surface water have also been monitored. Usually microbiological monitoring confirms with appropriate ISO or EPA standards. Only a few water companies are involved in research in this area, although projects have been initiated by regional and international associations.

Czech Republic

Some 87% of the population are provided with mains drinking water of which 60% is from surface water. Water quality standards follow the World Health Organization recommendations of 1984. Responsibility for monitoring of water quality and surveillance of infectious disease is the responsibility of the Czech hygienic service. *Cryptosporidium* spp. has been detected in surface water at counts of between 40 and 32,000 oocysts/100L. In drinking water, counts ranged from 0 to 5,800 oocysts. The higher counts were detected following back washing of filters. A sero-epidemiological study for the prevalence of antibodies to cryptosporidiosis is currently being planned.

Denmark

Almost the entire water consumption in Denmark is based on groundwater abstraction. Because of the reliance on groundwater, a major factor in ensuring the safety of drinking

water in Denmark is aquifer protection. Treatment of groundwater is basically oxidation and filtration. Danish water quality standards follow on from the European Union. A study of the presence of *Cryptosporidium* oocysts in drinking water was to be completed in 2001. A survey of water for the presence of *Helicobacter pylori* was unable to detect its presence in groundwater, surface water or treated water.

Finland

In Finland the responsibility for water quality is covered by the Health Protection Act and rests with the Ministry of Social Affairs and Health. The responsibility for routine drinking water monitoring rests with the local health authority, though this may be devolved to the water supplier. Finland has recently adopted the new European Drinking Water Directive. Whenever the quality of water or cases of illness in the community causes concern for waterborne disease, the Health Authority is obliged to inform customers and take appropriate action. Health Authorities also report to the National Public Health Institute. Currently Finland is funding four main projects, waterborne viral infections, *Cryptosporidium* and *Giardia*, cyanobacterial toxins, and undesirable biomass in water distribution.

Germany

Groundwater is the major source of drinking water in Germany and "Water Protection Areas" have been a long established means of protecting water safety. For surface water standard multiple barrier approaches are applied. Turbidity is the main method for treatment control. Monitoring of source and treated waters for pathogens is not routinely undertaken and there is no national database of the results of any pathogen monitoring activity. Responsibility for investigating potential waterborne outbreaks rests with the health authorities. Research currently concentrates on improving methods for detection of *Cryptosporidium* and *Giardia* and on the occurrence and significance of caliciviruses in water.

Hong Kong Special Administrative Region, China

All water in Hong Kong all raw waters are treated by coagulation, filtration and chlorination. Raw and treated waters are regularly tested for *Cryptosporidium* and *Giardia* and significant levels have not yet been detected in the water supply. A vigilance level of 1 oocyst in 10 litres has been set for *Cryptosporidium*. To date there have been no detected outbreaks linked to drinking water of either protozoan pathogen

Japan

Two outbreaks of cryptosporidiosis linked to the water supply have been identified in Japan. The first one was in 1994 and affected 461 known cases. The second, in 1996, affected some 8,800 people. As a result of the second outbreak Japan established a 'Provisional Guideline for Protection of Waterworks from *Cryptosporidium*' This sets a provisional guideline of essentially absence of *Cryptosporidium* and *Giardia* in 20L. Between 1996 and 2000 several small waterworks have had to stop supply as a result of this guideline, though no cases were detected in the community following detection of oocysts. Following a survey of source waters it was found that both *Cryptosporidium* and *Giardia* were present in river waters at levels ranging from 1 to 10,000 oocysts in 100L. Municipal wastewater contributed insignificant amounts, but swine wastewaters are significant sources of pollution. Recently the debate about standards for protozoa in drinking water has restarted.

Korea

To-date there have been no outbreaks of disease linked to public water supplies in Korea, though there have been some small outbreaks detected associated with small private

supplies. Consequently there is no significant demand for pathogen monitoring in drinking water at present. Water safety in Korea depends on, source water protection, water treatment (usually with multiple barriers) and coliform counts. Nevertheless, rising expectations about water safety in Korea are generating interest in the issue of health related water microbiology.

Norway

Norway has implanted the European Directive. In general drinking water sources are chosen from protected catchments, though in vulnerable water sources additional treatment is used. In a survey of raw waters undertaken in 1998 and 1999, *Cryptosporidium* oocysts were detected in 25% of samples, at concentrations of between 1 and 3 oocysts in 10L. Responsibility for the investigation of disease outbreaks rests with the medical officer of the affected area. During the 10 years 1990 to 1999, there were 40 outbreaks associated with drinking water, of which 18 were of unknown cause, 10 were due to *Campylobacter*, 8 due to Norwalk virus, 3 due to *Salmonella*, and one each due to *Shigella* and Hepatitis A. No outbreaks were found due to *Cryptosporidium*.

Poland

Protection of public health against waterborne disease is the responsibility of the Ministry of Health with day-to-day responsibility devolved to local sanitary departments. In general microbiological methods confirm to ISO standards. The Ministry of Health is responsible for investigating outbreaks of disease and advising consumers. Research is currently being undertaken into methods of culture of *Legionella* sp., the prevalence of *Campylobacter* in surface waters was about 36%, though the pathogen was never isolated from treated waters. Research was also undertaken into the prevalence of *Campylobacter* in rodents. Research into *Cryptosporidium* and *Giardia* include evaluating diagnostic methods.

Portugal

In 1998, some 87% of the population was connected to a mains water supply. All water suppliers undertake total coliform, faecal coliform, *E. coli* and *Streptococcus* sp. testing. Two water suppliers are testing water for *Cryptosporidium* and *Giardia*. Laboratories follow international standards for laboratory methods. Portugal expects to further develop testing for *Cryptosporidium* and *Giardia*.

Romania

The responsibility for water quality legislation rests with the Ministry of Health through the Institute for Public Health. There are low levels of source protection and no means for removal of nitrogen or phosphorus. Petroleum products, chlorides and sometimes cyanides and phenols appear above permitted levels. Water chlorination is done with out-of-date equipment which does not allow accurate dosing. However, it is expected that the European directive will be adopted in Romania.

Slovakia

Currently there is no evidence of the presence of either *Cryptosporidium* or *Giardia* in drinking water supplies in Slovakia. However, from 2001 all drinking water sources will be monitored for these organisms. In Slovakia there is a program of monitoring drinking water for fungal micromycetes. Such organisms are detectable in water. The range of bacteria looked for in water is much the same as elsewhere. Nevertheless, most drinking water samples yield no pathogens.

South Africa

The provision of suitable water and sanitation is a central component of the South African government's Reconstruction and Development programme. A major obstacle to the implementation of this programme is the unwillingness of rural communities to pay for water and they continue to use traditional and unsafe sources. South Africa has suffered a major cholera epidemic with over 50,000 cases and 11 deaths reported. It is the rural communities that appear most at risk. Concern about *Cryptosporidium* and *Giardia* is relatively low in South Africa, though this may be because of other more pressing problems. Currently catchment management is not universally applied in South Africa, though Catchment Management Authorities are due to be set up. Most of the larger water suppliers use conventional water treatment processes. Few laboratories are able to detect protozoan parasites in water. Other water standards are derived from WHO guidelines. Clinical surveillance techniques are probably not sufficiently refined to detect anything but very large outbreaks of waterborne disease.

Spain

As with most countries, Spain does not have legislation requiring the routine sampling of water for *Cryptosporidium* or *Giardia*. However, some laboratories do have the expertise to test water for these pathogens. Three methods have been used to examine raw waters and mean levels identified vary markedly between the methods. The most effective seems to be the EPA method. There have been studies of the effectiveness of water treatment plants at removing *Giardia* (99.9996%) and *Cryptosporidium* (99.94%).

Sweden

Sweden tends to follow European directives when setting its water quality guidelines. However, current legislation has more of a HACCP approach than other states. Swedish law requires multiple barriers depending on the microbiological quality of raw water. The most common cause of waterborne outbreaks in Sweden is *Campylobacter* and the organism is found in 2.6% of surface waters. Local health protection board is responsible for overseeing the quality of drinking water supplies and for investigating outbreaks of infectious disease.

United Kingdom

The UK currently follows the standards laid out in the European Community Drinking Water Directive 80/778/EEC, though new water regulations have been enacted and by 25 December 2003, the UK will follow the new European Directive 90/83/EC. The water industry in England and Wales was privatised in 1989 and there are now 10 large water and sewerage companies and 15 water supply only companies. In Scotland and Northern Ireland, the water supply industry remains in public ownership. In 1999 in the UK there were almost 3.1 million tests done to check compliance with the European directive, of which 99.71% were compliant. Responsibility for the surveillance of infectious disease possibly linked to water and the investigation of possible outbreaks rests with local and health authorities at the local level and with the Communicable Disease Surveillance Centre, nationally. Following outbreaks of disease, new regulations came into force in June 1999 that set a treatment standard for *Cryptosporidium* of <1 oocyst in 10 litres averaged over about 1000L sampled during a single 24 hour period. This standard was not set on health grounds, but rather on the basis that this level was readily achievable in a well operated conventional treatment plant. Water companies were obliged to undertake a risk assessment of each of their water treatment works. For those considered to be at significant risk of contamination by *Cryptosporidium*, there is a legal requirement to undertake contin-

uous monitoring with about 1000L being sampled each day. Some 332 of 1481 water treatment works have been identified as being at significant risk. At the time of writing the report, 25,022 samples had been taken from 166 sites. Oocysts were detected in 9.11% of samples taken, and 44.6% of sites yielded at least one positive sample. Most positive samples (85.55%) were in the range 0.01 to 0.10 oocysts per 10L. Six results from three sites have contravened the treatment standard and in none of these occasions were cases of illness subsequently detected in the community.

