



In this Issue:

Walkerton Inquiry Second Report	1
Conference Reports	
<i>Heterotrophic Plate Count Bacteria in Drinking Water - Public Health Implications?</i>	3
<i>10th Canadian National Conference and 1st Policy Forum on Drinking Water</i>	6
News Items	8
From the Literature	10
<i>Arsenic</i>	
<i>Bottled Water</i>	
<i>Cancer</i>	
<i>Cholera</i>	
<i>Cryptosporidium</i>	
<i>Detection Methods</i>	
<i>Disinfection Byproducts</i>	
<i>Drinking Water Treatment</i>	
<i>E. coli O157</i>	
<i>Gastrointestinal Illness</i>	
<i>Legionella</i>	
<i>Leptospirosis</i>	
<i>Wastewater Contaminants</i>	

Additional Articles	20
---------------------	----

Editor Martha Sinclair
Assistant Editor Pam Lightbody

CRCWQT Internet Address:
www.waterquality.crc.org.au

A searchable **Archive** of Health Stream articles, literature summaries and news items is available on the Web page.

Walkerton Inquiry Second Report

The Second Report of the Walkerton Inquiry was released on 23 May 2002. Delivery of the report completed the work of the judicial inquiry appointed by the Ontario government after the May 2000 waterborne disease outbreak that resulted in the death of seven people in the small Ontario town. The mandate of the Inquiry was divided into two parts; the first, an examination of the events in Walkerton and the causes of the outbreak; the second, a broad ranging review resulting in the development of recommendations to ensure the safety of drinking water across Ontario. During its investigations the Inquiry was assisted by a Scientific Advisory Panel, and commissioned a number of expert papers reviewing current literature and international best practices in drinking water management, regulation and technology. The report covering the first part of the mandate was released in January this year (1).

In its Second Report, the Inquiry made 93 recommendations for eleven key areas of water supply management. The major recommendations may be summarised as follows:

General Principles

The Head of the Inquiry, Justice Dennis O'Connor, stated that the aim of his recommendations was to "ensure that Ontario's water supplies deliver water with a level of risk so negligible that a reasonable and informed person would feel safe drinking the water". This goal can be achieved by utilising the multiple barrier approach to prevent contaminants reaching consumers, cautious decision-making in regard to water safety, ensuring that sound quality management and operating systems are used by water providers, and by effective regulation and oversight on the part of the provincial government.

Commenting on the potential costs of implementing the recommendations of the Inquiry, he noted that average water rates compare favourably to many other less essential household services. The costs of the Walkerton outbreak have been estimated at over CDN \$64 million. This includes direct medical costs, projected costs for medical treatment for those with long-term health effects, costs to households and businesses, and the costs of the investigation, water system clean up and the Walkerton Inquiry.

Source Protection

The Inquiry recognised the importance of source protection as the first barrier in drinking water protection, and recommended the implementation of a coordinated source protection program. This would be implemented in the context of overall management plans for individual watersheds. The framework for developing such programs should be the responsibility of the Ontario Ministry of the Environment (MOE), with planning at the local level being undertaken by local conservation authorities in consultation with municipalities and other stakeholders. The MOE should also have responsibility for approval of the management plans. Individual water protection plans should be required for all large or intensive farms, and for smaller farms in sensitive or high-risk areas. Planning processes for other catchment activities should also take into account their potential impact on water supplies.

Standards and Technology

It was recommended that the process by which Canadian federal and provincial governments set drinking water standards should be made more transparent and accessible to public participation, and that adequate scientific support be made available to this process at both provincial and federal levels. The Inquiry emphasised that the design and approval of drinking water treatment systems should be based on characterisation of health-related parameters in the raw water source, regardless of the type of source (2).

Recognising the need for preventive rather than reactive management strategies, the Inquiry recommended that minimum requirements for municipal water suppliers should include continuous

inline monitoring of turbidity, disinfectant residual, and pressure at the treatment plant. Such monitors should be connected with alarms and automatic shut off mechanisms. Disinfectant residuals should also be monitored continuously or frequently in distribution systems. Specific recommendations were also made for laboratory accreditation, and standardisation of water quality sampling and analysis.

Municipal Water Providers

The majority of Ontario residents (over 80%) are currently supplied by municipally owned water systems, and the Inquiry concluded that none of the evidence or views presented during the investigation convinced it of the need to make recommendations on the ownership of water supply systems. The Inquiry recommended the development and implementation of a quality management approach for water supplies through a mandatory system of accreditation and operational planning. This approach should emphasise the importance of preventive rather than reactive management to protect public health. To promote accountability it also recommended that the municipal officers responsible for overseeing the management and operation of the water supply be held to a statutory standard of care. The quality management system should include requirements for mandatory certification of system operators. Recognising that good management requires adequate resourcing, the Inquiry also recommended that each municipality should be required to develop a financial plan incorporating full cost recovery and allowance for proper asset management of the water supply system.

Provincial Oversight

In its Part 1 Report, the Inquiry noted that failure of the provincial government to exercise effective oversight was a contributing factor to the events that occurred in Walkerton. To rectify these shortcomings, the Inquiry recommended the development of a comprehensive source-to-tap drinking water policy, and enactment of a *Safe Drinking Water Act* embodying the important elements of that policy. This should be supported by internal restructuring of the MOE to create a Watershed Management Branch responsible for coordinating and overseeing watershed planning, and

a Drinking Water Branch responsible for overseeing water treatment and distribution systems. The Inquiry also recommended streamlining current separate approvals and certifications for drinking water systems into a single owner's licence covering all required aspects for operating a waterworks.

Special Cases

The report of the Inquiry included specific consideration of small water systems and First Nations water systems (on native American reserves). Small water systems in Ontario fall into two categories: those supplying several households or designated facilities (schools, hospitals, nursing homes) that are covered by current Ontario regulations, and some privately owned systems that presently fall outside the regulations but supply water to the public (such as rural restaurants, summer camps and resorts). The Inquiry recommended that all water systems supplying water to the public be covered by appropriate regulations. While noting the cost burden imposed on small systems by regulatory requirements, the Inquiry recommended that any variances from provincial standards should be granted only on the basis of satisfactory risk assessment, not economic hardship. Those systems currently not covered by regulation should have the choice of complying or declaring their supply non-potable with appropriate signage to inform the public.

First Nations water supplies are not under the jurisdiction of the Ontario government but are the responsibility of the traditional land owners and the federal government. Thus the Inquiry was limited in its ability to make recommendations in this area, however it noted that many of these water supplies are of poor quality. The Inquiry suggested that the First Nations and the federal government should adopt standards no lower than those applied in the rest of the province, and that the provincial government should make resources and expertise available on a cost recovery basis to enable the improvement of water quality on reserves.

- (1) Reported in Health Stream Issue 25, March 2002.
- (2) The Walkerton outbreak was in part attributable to the belief that the groundwater source was not prone to significant faecal contamination, despite a history of microbiological evidence to the contrary.

Conference Reports

Heterotrophic Plate Count Bacteria in Drinking Water - Public Health Implications?

22-24 April 2002, Geneva, Switzerland.

By Dr David Cunliffe, Department of Human Services, South Australia.

Heterotrophic plate count (HPC) testing has a long history of use in water microbiology. At the end of the 19th century Robert Koch demonstrated from investigations of cholera outbreaks that HPC could be used as an indicator of the proper functioning of sand filtration and hence as an indirect indicator of water safety. Since then, the use of HPC has had a varied history.

During the 20th century use as a direct indicator of public health safety of drinking water declined with the development of more specific faecal indicator organisms but HPC measurements have continued to feature in some guidelines and regulations. In addition to testing of drinking water, HPC have been included in some regulations for bottled water and point-of-use devices manufactured for household treatment of drinking water. The suggestion that measurements of total bacterial load might provide an indication of the presence of pathogens or the potential for pathogens to survive or grow has been keenly debated for many years.

In an attempt to reach a scientifically based consensus on the significance of HPC, the National Sanitation Foundation and the WHO Collaborating Centre for Drinking Water Safety and Treatment convened an International Symposium in Geneva on 22-24 April 2002 to discuss the appropriate use and interpretations of HPC measurements in drinking water. The symposium was intended to set the stage for a WHO Expert Meeting on 25-26 April 2002 which had the aim of producing a consensus scientific position on HPC.

The symposium was attended by 182 participants from over 27 countries, comprising a prestigious array of international water microbiologists, epidemiologists and clinicians together with representatives from manufacturers of point-of-use devices and from the bottled water industry.

Thirty five papers and 14 posters were presented at the symposium. Topics discussed included:

- The history and use of HPC
- Regrowth bacteria
- HPC bacteria of concern
- Relationships between HPC and pathogens in drinking water
- Epidemiological evidence of illness linked to HPC bacteria
- Infectivity and vulnerable populations
- Methods, standards and guidance

The principal finding of the symposium was that there was no evidence that HPC testing alone directly relates to health risk. Accordingly HPC are not appropriate for public health assessment of drinking water quality or for setting health related guidelines. Sudden increases in HPC can sometimes be associated with faecal contamination but tests for specific faecal indicators such as *E.coli* are required to determine the existence of potential health risks. The symposium concluded that while HPC could not be used as an indicator of water safety, they could be used for assessing the effectiveness of water treatment processes or system integrity and in the investigation of aesthetic water quality.

Health Implications

A range of epidemiological studies, case investigations and human and animal challenge studies have been undertaken to examine the possible relationship between HPC and human health effects. A detailed review of this work concluded that no direct relationship has been established between ingestion of HPC in drinking water and human health effects in the general population.

This conclusion is supported indirectly by evidence from exposures to foodstuffs where presence of HPC is acknowledged. Numbers of HPC in foods are several orders of magnitude higher than those in drinking water and there is no evidence, in the absence of specific pathogens, that this general group of organisms represents a human health risk. The species of heterotrophic bacteria found in foods are similar to those in water. One study estimated that HPC from tapwater represented less than 0.002% of HPC bacteria ingested by the general public.

It has been suggested that HPC may have health implications because the test could include measurement of a range of opportunistic pathogens or that it could provide an indication of the presence of such organisms. So-called opportunistic pathogens that may be recovered in HPC testing include strains of *Pseudomonas aeruginosa*, *Aeromonas*, *Klebsiella* and *Acinetobacter*. Discussions at the Symposium concluded that for the general population there is no evidence that these organisms are associated with gastrointestinal infection arising from ingestion of tapwater. Accordingly the presence of these organisms in HPC measurements did not represent a public health risk associated with drinking water.

There are other opportunistic pathogens such as *Legionella* and non-tuberculous mycobacteria which can grow in water but are not detected in HPC measurements. It was concluded that there is no evidence that HPC can be used to reliably indicate the likely presence of these types of potentially pathogenic regrowth bacteria.

The susceptibility of vulnerable populations including the immunosuppressed was also discussed. Increasing numbers of immunocompromised people are living at home. However, except for the severely immunocompromised it was considered that no modifications of water quality were required and that there was no increased requirement for monitoring of HPC. The increased risk of the severely immunocompromised is related to general water safety and not specifically to HPC organisms. The needs of this group required specialist advice and interventions in relation to drinking water and other exposure sources.

Some species of microorganisms included in HPC measurements can cause infection in those undertaking specific procedures such as continuous peritoneal dialysis or in those with devices such as urinary and intravenous catheters. However, most infections due to these organisms arise from non-water sources such as cross-infection from other persons or from exposure to endogenous or environmental microorganisms.

Management of Water Systems

Although HPC are not suitable indicators of drinking water safety they are relatively inexpensive tests that can be used to monitor the effectiveness of water treatment processes or activities. This can be undertaken to validate that processes will be effective before use or verify that the processes have been effective after use.

Suggested examples include:

- assessing procedures for cleaning and maintenance of distribution mains and storages
- testing new processes for removal or disinfection of pathogens
- testing the effectiveness of point-of-use devices
- assessing bacterial regrowth potential
- assessing finished water quality changes during distribution
- monitoring water quality after repairs to infrastructure
- using HPC as an indicator for nitrification in chloraminated supplies
- testing for microbial growth as a cause of taste and odours

Interpretation of results was discussed. A number of guidelines or regulations refer to the use of HPC for monitoring of water quality. Some set guideline values or numerical standards, while others state that there should be '*no abnormal change*'. It was suggested that the latter approach is more in keeping with the use of HPC as an operational tool for water quality management. Changes should be assessed in terms of orders of magnitude.

Use of HPC for monitoring the safety of bottled water and water produced by point-of-use devices

Like mains water, bottled water is generally not sterile. Bottled water contains no long lasting disinfectants and after production may be kept at room temperature for days or weeks prior to consumption. Under these conditions numbers of HPC much higher than those in mains water may develop but there is no suggestion that this represents a health risk. Monitoring of HPC might be useful as part of process management in the production of bottled water but not as a measure of deterioration in safety during storage prior to consumption.

Growth of HPC can also occur in point-of-use devices including water softeners, carbon filters and water coolers. While growth may influence aesthetic quality including taste and odour, in the absence of faecal contamination, it does not indicate existence of a health risk.

Methods for Analysis

Heterotrophs are defined as microorganisms including bacteria and fungi that require organic carbon for growth. There are a variety of culture-based methods that have been developed to isolate and enumerate these organisms. There is no standardised test and a range of media, incubation temperatures and times are used. It was noted that a common feature of all culture-based methods is that they only isolate a very small proportion of metabolically active microorganisms present in water. Investigations have shown that the percentage of organisms detected will vary widely between seasons and from different locations and will be influenced by environmental conditions.

Improvement of HPC methods will not change the status that tests for these organisms as a group lacks public health significance. However presentations were provided that demonstrated new technologies being developed have the potential to greatly enhance the analysis of complex mixtures of organisms and to identify within these mixtures specific pathogens. Rapid and automated tests that will improve the use of total bacterial counting as an operational monitoring tool are also being developed.

Further Information

Summaries of the outcomes of the expert meeting and the conference sessions will be published by International Water Association, and selected peer-reviewed papers will be published in the International Journal of Food Microbiology.

The remaining papers are available separately in the Conference Proceedings.

<http://www.nsf.org/conference/hpc/>

10th Canadian National Conference and 1st Policy Forum on Drinking Water

27-30 April 2002, Halifax, Nova Scotia, Canada.

By Ms Samantha Rizak, Monash University & CRC for Water Quality and Treatment

This conference was attended by over 300 delegates from across Canada and abroad. In the past two years, the major waterborne disease outbreaks at Walkerton and North Battleford have raised the profile of drinking water quality and safety in Canada as well as internationally. The theme of this year's conference, *From Source to Tap – Protecting Drinking Water in Small Systems*, reflected this heightened interest and as the theme suggests, many of the paper and posters presented dealt with drinking water issues that are of particular concern to small drinking water systems.

This event also marked the first National Policy Forum on Drinking Water. This forum included individual keynote presentations and discussion panels on a variety of issues including current and future regulatory options, financing utility infrastructure and operations, and Canadian research activities and needs.

The conference sessions were organised into the following topics with a focus on small system issues and needs:

- The changing regulatory framework
- Microbiological water quality
- Treatment technology and management
- Disinfection
- Disinfection by-products
- Source protection
- Outbreaks and endemic illness
- Distribution systems
- Small system issues and needs
- Security and liability

Each session comprised several presentations. Poster presentations were also displayed throughout the conference and a poster exhibit was held as an opportunity to meet authors and discuss research findings. This report outlines several sessions of the conference. The conference proceedings will be published in late 2002/early 2003

The conference was opened by the Honourable David Morse, Nova Scotia Minister of Environment and Labour. The keynote address was given by Dr. Jamie Bartram, coordinator of the Water Sanitation and Health Programme of the World Health Organisation, who provided a background on the WHO Guidelines for Drinking-Water Quality and the evolving WHO drinking water program focussing on a harmonised framework for guidelines and standards and more effective approaches to manage safe drinking water.

The revised WHO Guidelines are targeted for publication in 2003 and will include five key components: health-based water quality (safety) guidelines, system assessment, effective management and documentation of management plans, and independent surveillance.

The Changing Regulatory Framework – this plenary session opened with a presentation on the current activities of the Federal-Provincial-Territorial Drinking Water Subcommittee, which develops and publishes the *Guidelines for Canadian Drinking Water Quality*. Information regarding development of future guidelines was presented and a new guidance document based on the multiple barrier approach, *Guidance for Safe Drinking Water – From Source to Tap* was described (1). This session also addressed the current limitations of protecting public health through monitoring of drinking water quality for compliance. The inherent shortcomings of sampling and analytical techniques, the limitations of indicator bacteria and the reactive nature of monitoring and the need for more effective approaches to managing drinking water quality and protecting public health were highlighted.

The feasibility of the Hazard Analysis and Critical Control Point (HACCP) system, developed for the food industry to reduce or prevent the health risks associated with food processing, was considered for drinking water systems. Key features of the HACCP system include the identification of hazards and assessment of risks, identifying the preventive measures to control hazards, and determining which measures can be controlled along with their control measures emphasising those elements that can be monitored in real time. Also necessary is the

documentation to demonstrate and verify that the critical activities are working and are effective. By focussing efforts on specific critical activities in a process, where monitoring can provide a real time measure of operational effectiveness, HACCP has the potential to improve performance and assure safety of drinking water.

The *Framework for Management of Drinking Water Quality* that the Australian National Health and Medical Research Council (NHMRC), in collaboration with the CRC for Water Quality and Treatment, has developed for incorporation into the Australian Drinking Water Guidelines was also presented. The Framework introduced the quality management approach designed specifically for drinking water supply systems which provides a comprehensive and preventive risk management strategy from catchment to consumer.

The Framework addresses four key areas:

- Commitment to Drinking Water Quality Management
- System Analysis and Management
- Supporting Requirements, and
- Evaluation (Audit) and Review

The Framework represents a significantly enhanced approach to the management and regulation of drinking water quality and offers a flexible and proactive means of optimising drinking water quality and protecting public health.

Microbiological Water Quality – as it is not feasible to directly monitor for all human pathogens (bacterial, viral, protozoan) for the protection of public health, indicator bacteria has long been used to assess the microbiological quality of drinking water quality. A history of the use of microbial indicators was presented and the significance of monitoring total coliforms for public health and its reliability in assessing human pathogens was discussed. It was noted that routine monitoring of total coliforms is not valuable as a public health indicator but may be appropriate for process control and to monitor treatment effectiveness. The potential roles of other indicator organisms were discussed but it was acknowledged that *Escherichia coli* has consistently been shown to be the most efficient indicator in

drinking water supplies as it is found in all mammal faeces and does not multiply appreciably in the environment.

New rapid and specific methods for detection of *E.coli* such as Colilert using Defined Substrate Technology were also presented as rationale for abandoning total coliforms, which originally served as a surrogate for *E.coli* because of early method deficiencies. However, it is also recognised that indicator bacteria do not reliably assess the presence of cyst-forming protozoa or enteroviruses. Thus, in addition to *E.coli* monitoring, there is a need to also monitor indicators of treatment efficiency such as chlorine residual for disinfection and turbidity for filtration. A comprehensive monitoring program incorporating these aspects should provide assurance to the safety and quality of drinking water supplies.

New research was presented on in this session on the occurrence of *Legionella* in groundwater samples. *Legionella* are opportunistic pathogens that are ubiquitous in surface water environments, but there is little information on their occurrence in groundwaters. The presence of *Legionella* in water storage and distribution systems has been well documented and has been associated with both community-acquired and nosocomial outbreaks. This study was recently undertaken to determine whether *Legionella* could be isolated from water and biofilm in groundwaters from various locations in the United States and Canada in both cold and warm systems. In a total of 114 samples (both water and biofilm), approximately 30% of samples were positive for *Legionella* with concentrations ranging from 10^2 – 10^5 CFU/L in water and up to 1.2×10^2 CFU/cm² in biofilm. Both known pathogenic and non-pathogenic *Legionella* sp. were identified in the samples. Because of the widespread reliance on groundwater as a water source, these results indicate that the presence of these bacteria should be considered when looking at potential public health impacts of using groundwater for drinking and domestic use.

Disinfection By-Products – presentations in this session included a survey of chlorinated disinfection by-products in small systems, water treatment processes and alternatives and to control chlorinated

disinfection by-products, and the effect of chlorine dioxide and its by-products on human health. The latter study explored the effect of chlorine dioxide and its by-products on the thyroid function of newborns and infants by comparing three municipalities with varying degrees of chlorine dioxide use. Using the results of screening for congenital hypothyroidism among 10,550 newborns, the average thyroid stimulating hormone was found to be significantly higher ($p=0.0001$) in the municipality using chlorine dioxide as the primary disinfectant, after adjusting for age at screening and birthweight. The results of this study are preliminary but indicate the need to research the possible effect of chlorine dioxide by-products on susceptible subjects such as newborns and infants.

Outbreaks and Endemic Illness – Evidence relating to the causes of the Walkerton outbreak was reviewed and compared with published causes of previous waterborne disease outbreaks in developed countries to gain a better understanding on why failures in drinking water safety continue to occur. Fifteen outbreaks from four countries over the past thirty years were described and failure modes were analysed in relation to each stage of the multiple barrier approach (source water, treatment, distribution, monitoring and response). The analysis suggested common themes and similar failure modes of many of the outbreaks. Among these, it is recognised that most outbreaks are preceded by changes in environmental conditions, typically heavy rainfall or runoff from heavy snowmelt. Thus an ability to recognise patterns that are associated with contamination potential is essential in the provision of safe and high quality drinking water. Complacency was also highlighted as an endemic problem underlying waterborne disease outbreaks in developed countries and that many failures are preventable.

It was concluded that a major challenge for improving drinking water system safety is to reform the pervasive culture of complacency that has been evident among the organisations involved in managing drinking water systems. Such complacency must be replaced with a culture of personal responsibility and vigilance.

Policy Forum – this aspect of the conference comprised individual keynote presentations and panels to encourage discussion on a variety of topics. The first policy forum addressed the future regulatory environment and the role of government at the federal and provincial level. Representatives from government departments discussed the response to drinking water safety in Canada triggered by the Walkerton outbreak and reviewed aspects of current and projected legislation. The roles and responsibilities of various agencies were highlighted and the liabilities of municipalities explained. The joint responsibility between drinking water suppliers, the agencies that oversee them and the public was emphasised, together with the need for a broad-based approach to the challenges of improving drinking water safety.

Discussions also included the potential role of standards and accreditation programs including the ISO9001 for Quality Management Systems, the American Water Works Association's QualServe and related accreditation programs, the Australian Framework for Management of Drinking Water Quality, and a proposal to develop an international standard for service activities relating to drinking water supply and sewerage.

(1) Available at www.hc-sc.gc.ca/waterquality

News Items

Australian Drinking Water Guidelines

Revisions to the ADWG are expected to be released for public comment during July 2002. The latest changes, carried out as part of the ongoing rolling revision process, include:

- restructuring of the guidelines document to incorporate the Framework for Management of Drinking Water Quality
- revisions to the Fact Sheets for *E.coli* and Thermotolerant Coliforms (FS 3), and for Coliforms (FS 4)

The three month consultation period will be advertised nationally and the documents will be available on the web site of the National Health and Medical Research Council.

<http://www.health.gov.au/nhmrc/>

Delays in Arsenic MCL to be permitted

The US EPA's National Drinking Water Advisory Council has approved a plan to allow small water utilities until 2015 to comply with the new arsenic standard. The Maximum Contaminant Level of 10 micrograms/litre is due to come into effect in January 2006, but the plan would allow systems serving less than 3,300 people to continue supplying water at 20 micrograms/litre for a further nine years. Larger systems would be allowed to deliver water with up to 35 micrograms/litre until 2009.

Critics have attacked the plan, passed narrowly by an 8-6 vote of the committee, as allowing too much leniency for water suppliers, and for sending confusing messages to the public over the health risks from arsenic. Regulations under the Safe Drinking Water Act are normally phased in over a period of 5 years to allow water utilities to make the required changes to plant and procedures before full compliance is reached.

Hard water linked to contact lens infections

British researchers have reported an association between cases of acanthamoeba keratitis (an infection of the cornea that can rapidly lead to scarring and sight loss) with the hardness of tap water supplies.

The incidence of the infection was three times higher among contact lens wearers living in hard water areas compared to soft water areas. This association suggests many wearers are allowing their lenses or storage containers to come into contact with tap water, rather than using the recommended sterile solutions or boiled water for cleaning and storage.

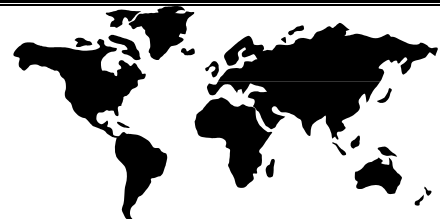
Resistant bacteria contaminating groundwater

At the May meeting of the American society for Microbiology, scientists from the University of North Carolina presented evidence that antibiotic resistant bacteria from intensive pig farms were contaminating nearby groundwater sources. Researchers compared the rate of isolation and antibiotic resistance profiles of enteric bacteria from 3 wells on or near pig farms with a well on a crop-growing farm that did not spread manure.

The study showed higher rates of occurrence of enteric bacteria in wells on or near pig farms. The bacterial strains were also more likely to be resistant to a larger number of antibiotics compared to bacteria isolates for the control (crop farm) site. Both manure lagoons and land spreading of manure were associated with higher levels of contamination with resistant bacteria. These results are of potential public health concern as many residents in these areas drink untreated groundwater.

Circulation Report – Issue 26 June 2002

Circulation for the print version of this issue is 3274 copies, with readers in 55 countries. A further 132 readers are registered for email notification of new issues.



Australia	2538	Greece	4	Luxembourg	1	Singapore	6
Algeria	1	Hong Kong	23	Malaysia	22	Slovenia	2
Argentina	1	Hungary	1	Mexico	1	South Africa	11
Austria	3	India	17	Morocco	4	Sri Lanka	2
Belgium	3	Indonesia	2	Myanmar	1	Sweden	3
Brazil	2	Iran	1	Nepal	1	Switzerland	4
Cambodia	1	Israel	9	Netherlands	13	Thailand	10
Canada	32	Italy	3	New Zealand	22	Togo	1
Chile	8	Ivory Coast	1	Norway	4	UAE	1
Chinese Taipei	18	Japan	70	Palestine	1	UK	60
Denmark	1	Jordan	2	Pakistan	4	USA	101
Finland	2	Korea	1	Papua New Guinea	5	Vietnam	2
France	26	Lebanon	1	Philippines	7	Yugoslavia	1
Germany	33	Lesotho	1	Russia	2		

From the Literature

Arsenic

Males in rural Bangladeshi communities are more susceptible to chronic arsenic poisoning than females: Analyses based on urinary arsenic.

Watanabe C, Inaoka T, Kadono T, Nagano M, Nakamura S, Ushijima K, Murayama N, Miyazaki K, Ohtsuka R. *Environ Health Perspect* (2001) **109**(12) p1265-70.

This study examined the dose-response relationship of chronic arsenic exposure and skin conditions in two rural communities in northwestern Bangladesh by measuring urinary arsenic concentrations. Individual arsenic levels in urine samples were compared with those in water from tube wells. Within house male and female comparisons were made to address any gender-related differences in susceptibility to arsenic toxicity. The results indicate that urinary arsenic concentration (corrected for creatinine) can be used as an indicator of recent exposure to arsenic. The urinary arsenic values for females were significantly higher than those for males. Skin manifestations were more severe in males than in females. In one community there was a dose-response relationship found between urinary arsenic and the degree of skin manifestation present in males. Gender differences however may be confounded by sunlight exposure and smoking. Further investigation in other communities is needed to confirm these results.

Elevated mortality from lung cancer associated with arsenic exposure for a limited duration.

Nakadaira H, Endoh K, Katagiri M, Yamamoto M. *J Occup Environ Med* (2002) **44**(3) p291-9.

In 1959 cases of arsenic poisoning were diagnosed in the town of Nakajo in Japan. The poisoning was due to ingestion of well water, which had been polluted by liquid wastes containing inorganic arsenic from a dye factory. Inorganic arsenic levels were up to 400 ppm in the waste fluid, and well water levels of up to 3ppm were detected. Residents were exposed to arsenic for 5 years from 1954 when groundwater flow in the region was reduced due to the building of

a riverbed. Of the 454 inhabitants who were medically examined at this time, 93 were diagnosed as having one or more symptoms of chronic arsenic exposure. In 1988, excess lung cancer mortality was detected 29 years after the poisoning ceased.

Mortality and survival studies were undertaken to examine the long-term health effects of the 5-year arsenic exposure by comparing a cohort of exposed symptomatic patients (86 of the 93 people) with a large cohort of subjects from two other districts (728 and 552 people) in the same town which were not exposed from 1959 to 1992. In the mortality study the cause of death was analysed and the ratio of observed to expected deaths by cause of death and gender was calculated for each cohort. The survival study examined the effects of lung cancer mortality on the cumulative chance of survival during the 33 year study period.

A significant excess in deaths from lung cancer was found in the male patients (7 observed deaths vs 0.64 expected). There was also elevated mortality in men with lung cancer in the subgroups with higher clinical severities of symptoms. The cumulative chance of survival for exposed patients was significantly lower than that for the unexposed controls, and this appeared to be due mainly to excess lung cancer deaths. The authors suggest the observations indicate a long term elevated risk of lung cancer in men following a 5-year exposure period for arsenic in drinking water.

Comment The patients in this study had detectable signs of arsenic poisoning (dermal lesions, anaemia or enlarged liver) at the end of the 5 year exposure period, and represent about 20% of those examined from the exposed population. The authors note that the majority of men (97.4%) but few women (9.3%) in the patient group were smokers, but they were unable to obtain smoking data on the control groups. Smoking is a strong risk for lung cancer and some evidence suggests it may have a synergistic effect with arsenic exposure. No information is presented on other potential exposure sources - for example whether the patients may also have worked at the dye factory, or had other significant sources of arsenic exposure in addition to drinking water.

Evaluation of costs and benefits of a lower arsenic MCL.

Frost FJ, Tollestrup K, Craun GF, Raucher R, Stomp J, Chwirka J. JAWWA (2002) **94**(3) p71-80.

This paper reviews the costs and benefits of the USEPA decision to lower the maximum contaminant level (MCL) for arsenic in drinking water from 50 to 10 micrograms/L. The USEPA estimate that this will prevent between 6.9 and 33 deaths from bladder and lung cancer each year in the US and possibly prevent some cases of cardiovascular and hypertensive diseases. The magnitude of health risks from low level arsenic exposure and therefore the predicted health benefits from reducing exposure have been the subject of much scientific debate. The authors review the epidemiological studies of health risks from arsenic exposure, the models applied to extrapolate health risks for low level exposure, and the differing costs estimates for lowering the MCL developed by the EPA and the AWWA Research Foundation.

Depending on the assumptions used, the cost of each year of life gained by lowering the MCL may range from US\$ 0.6 million to US\$ 738 million. Even the lowest estimate in this range produces a cost about 10-fold higher than that commonly regarded as acceptable for life-prolonging medical treatments. Given that the cost of compliance will be heaviest for customers of small water supply systems, the authors suggest that adverse health effects from a reduction in disposable incomes in poor rural areas may outweigh any benefits from reducing arsenic exposure. They suggest that the high costs of the proposed arsenic MCL raise important public policy issues including the quality of evidence required for environmental policy decisions in contrast to other areas such as medical treatment and screening tests.

Bottled Water

Norwalk-Like Virus Sequences in Mineral Waters: One-Year Monitoring of Three Brands.

Beuret C, Kohler D, Baumgartner A, Luthi TM. Appl Environ Microbiol (2002) **68**(4) p1925-31.

A recent study reported Norwalk-like virus (NLV) in several brands of European mineral waters. This

study aimed to clarify the significance of these results by examining three commercially available European mineral water brands over time. A 1-litre sample of each brand was analysed weekly over 1-year period (April 2000 to April 2001). Samples were tested by reverse-transcriptase PCR using generic and genogroup-specific oligonucleotides. Additional analyses were performed to investigate possible correlation between NLV sequence contamination and lot numbers of mineral water, the long-term stability of NLV sequences in mineral water and the level of contamination. Of the 159 weekly samples examined, 53 were found to be NLV sequence positive, with all isolates belonging to genogroup II. All three brands of mineral water had approximately the same frequency of NLV sequence contamination (brand 1 - 30% of 53 tested samples, brand 2 - 36%, brand 3 - 34%). Sequence analysis of amplified NLV sequences showed that strains from each mineral water brand were closely related to each other but less similar to isolates from the other two brands.

Second samples of each mineral water found to be NLV positive were analysed to investigate possible correlations within lots. Forty-five out of the 53 second samples were positive for NLV genogroup II sequences. Ten of 10 samples were still positive after 6 months storage at room temperature in darkness, and 9 out of 10 were positive after 12 months. NLV was not detected in 0.1 litre samples of all 53 previously tested samples that were positive for 1 litre test volumes. This suggests a low concentration of NLV in the brands tested. Given the estimated method sensitivity limit of approximately 10 viral units, the levels of contamination in the positive samples were estimated to be between 10 to 100 genomic equivalents per litre.

Comment The authors note that the RT-PCR detection method is unable to demonstrate viral infectivity, and no cell culture method is available for NLV. However, they believe detection of NLV sequences after 12 months storage suggests the virus particles are largely intact and potentially infective. The origin of the contamination is uncertain. It may have occurred due to contamination of water sources or packing material or during the bottling process.

Chemical quality of bottled waters from three cities in eastern Alabama.

Ikem A, Oduyungbo S, Egiebor NO, Nyavor K. *Sci Total Environ* (2002) **285**(1-3) p165-75.

Bottled water including spring and purified bottled water types was purchased randomly from different supermarket stores in three Alabama cities in the USA. 25 brands were analysed for pH, conductivity, alkalinity, chloride, nitrate and nitrite, sulphate, phosphate, total carbon, inorganic carbon, total organic carbon and 27 elements. The results were then compared with the US Environmental Protection Agency (USEPA) drinking water standards and the European Union (EU) Drinking Water Directive. Some of the bottled water samples were found to have pH values, conductivity and essential and non-essential elements at levels exceeding the EU and USEPA drinking water standards. The authors note that the common perception of spring water as "pure" is erroneous and that adequate standards and quality control measures are required for bottled waters.

Cancer

Relationship between mineral and trace element concentrations in drinking water and gastric cancer mortality in Japan.

Nakaji S, Fukuda S, Sakamoto J, Sugawara K, Shimoyama T, Umeda T, et al. *Nutr Cancer -An International Journal* (2001) **40**(2) p99-102.

This study examined concentrations of 14 elements in drinking water from 34 water treatment plants in Aomori Prefecture, Japan and whether geographical variations were associated with gastric cancer mortality. The elements tested were aluminium, gold, boron, barium, calcium, iron, magnesium, lead, selenium, tin, strontium, tellurium, zinc and sodium. Japan has the highest incidence of gastric cancer in the world, and this may be partly attributable to the high salt content of the Japanese diet.

Using multiple regression analysis, a significant relationship was found between the age-adjusted mortality rate from gastric cancer and zinc, lead, strontium and selenium concentrations for men and lead, strontium and gold concentrations for women.

Selenium and zinc were found to be protective against gastric cancer, while strontium and gold were associated with increased risk. Lead was associated with an increased risk in men but a decreased risk in women. There was no significant relationship found for sodium and gastric cancer whereas previous studies have reported such a relationship.

Comment The authors note that important factors affecting stomach cancer risk such as *Helicobacter pylori* infection, and dietary intake of antioxidants were not assessed. For many elements examined here, food is likely to be a greater source of intake.

Cholera

Cholera prevention with traditional and novel water treatment methods: An outbreak investigation in Fort-Dauphin, Madagascar.

Reller ME, Mong YJM, Hoekstra RM, Quick RE. *Am J Public Health* (2001) **91**(10) p1608-10.

In March 1999 a cholera outbreak began in Madagascar eventually resulting in 37,000 cases and 2,200 deaths. This paper reports a case-control study of risk factors conducted in the city of Fort-Dauphin during February 2001. Among the factors assessed was a household-based safe water intervention using sodium hyperchlorite solution (promoted as Sur'Eau). Cases with clinical symptoms of cholera were matched with two controls from households free of diarrhea during the outbreak. Patients were more likely than controls to have drunk untreated water. Drinking heated rice water or water from a household tap was protective against cholera. Using Sur Eau or always boiling water also tended to be protective. Using soap to wash hands was also protective against illness. Untreated water was implicated as the main vehicle of epidemic cholera in Fort-Dauphin.

Cryptosporidium

Novel *Cryptosporidium* genotypes in sporadic cryptosporidiosis cases: First report of human infections with a cervine genotype.

Ong CSL, Eisler DL, Alikhani A, Fung VWK, Tomblin J, Bowie WR, Isaac-Renton JL. *Emerg Infect Dis* (2002) **8**(3) p263-68.

From 1995 to 1999, *Cryptosporidium* oocysts were isolated from patients in British Columbia with clinical symptoms consistent with cryptosporidiosis. Oocysts were genotyped by polymerase chain reaction (PCR) amplification of the internal transcribed spacer region, a hypervariable region in the 18S rRNA gene and the *Cryptosporidium* oocyst wall protein gene. PCR products were also characterised by restriction fragment length polymorphism and DNA sequencing.

Cryptosporidium oocysts from 150 sporadic cryptosporidiosis cases were characterised and two new genotypes of *C. parvum* were detected. One of these (found in 6% of isolates in this study) was recently reported in deer in New York State, the other (in 1.3% of isolates in this study) has not previously been described. This is the first report of human infection with the deer (cervine) *C. parvum* genotype. The authors note that deer and other wildlife present in watersheds may contribute to human infections in addition to the more common genotypes which are responsible for the majority of human cases.

Detection Methods

Improved method for concentration of *Giardia*, *Cryptosporidium*, and poliovirus from water.

Watt PM, Johnson DC, Gerba CP. J Environ Sci Health - Part A Toxic/Hazardous Substances & Environmental Engineering (2002) 37(3) p321-30.

Currently concentration of viruses and parasites from large volumes of water require the use of different types of filters. This study examined whether both protozoan parasites (*Giardia*, *Cryptosporidium*) and enteric viruses could be co-collected using the same filter. Concentration efficiencies of a polypropylene fibre cartridge (DPPPY) filter and two different microporous filters (Filterite and 1MDS) with poliovirus (type 1), with respect to their ability to concentrate *Giardia* and *Cryptosporidium* from water were compared. Each type of filter was tested for recovery of *Giardia* cysts and *Cryptosporidium* oocysts from both tap and tertiary treated wastewater.

The overall recovery efficiency for the DPPPY filter was 10.1 +/- 11.7 and 16.0 +/- 16.8% (geometric mean

and standard deviation) for *Giardia* and *Cryptosporidium* respectively in both types of waters. The overall recovery was higher and more consistent with the Filterite filter, 40.4 +/- 7.8 and 36.6 +/- 20.4% for *Giardia* and *Cryptosporidium* respectively from both types of water. The 1MDs filter had overall recovery efficiency of 20.4 +/- 7.8 and 18.1 +/- 6.0% for *Giardia* and *Cryptosporidium* respectively from both types of water. The recovery efficiencies from the tertiary-treated wastewater were higher than from tap water, especially using the Filterite filter.

The Filterite filters showed greater efficiency compared to the other filters and were easier and faster to process. The current methods used for recovery of these microorganisms have a low and variable efficiency. This study showed that both protozoan parasites and enteric viruses could be co-collected onto the same microporous filter, simplifying testing procedures.

Interference between enterovirus and reovirus as a limiting factor in environmental virus detection.

Carducci A, Cantiani L, Moscatelli R, Casini B, Rovini E, Mazzoni F, Giuntini A, Verani M. Lett Appl Microbiol (2002) 34(2) p110-13.

In Italy, regulations stipulate that drinking water, bathing areas and water sediments be tested for the presence of enteroviruses. Detection of enterovirus is traditionally based on the typical cytopathic effects of the virus on cell cultures, however a number of authors have reported that the presence of other viruses may inhibit the cytopathic effects. This interference hypothesis was tested in this study.

Cell cultures were co-infected with mixed suspensions of the polio type 3 virus and reovirus type 1 at stepwise dilutions. The cytopathic effects were observed and the presence of enterovirus tested for by RT-PCR. It was found that tests which are usually highly sensitive for the detection of enterovirus, had a considerably decreased sensitivity when reovirus was also present. The method's sensitivity may be reduced by up to almost two orders of magnitude. Therefore, tests conducted on waters with elevated concentrations of reovirus may underestimate or even fail to find enterovirus.

Disinfection Byproducts

Use of mechanism-based structure-activity relationships analysis in carcinogenic potential ranking for drinking water disinfection by-products.

Woo YT, Lai D, McLain JL, Manibusan MK, Dellarco V. Environ Health Perspect (2002) **110**(Suppl 1) p75-87.

Disinfection of drinking water results in the production of a wide range of DBPs from natural inorganic and organic matter in the water. For many DBPs there is little or no health or occurrence data and it is not feasible to perform detailed studies on all DBPs, therefore there is a need to prioritise research efforts. This article describes the process used by the US Environmental Protection Agency (EPA) to prioritise DBPs for future investigation, by examining DBPs using a mechanism-based expert structure-activity relationship (SAR) judgment with emphasis on genotoxic cancer potential. An extensive literature search for genotoxicity and other data was also conducted.

The EPA only considered DBPs that were detected in actual drinking water samples, have insufficient cancer bioassay data for risk assessment and have structural features/alerts or short-term predictive assays indicative of carcinogenic potential. These criteria resulted in culling of the initial list of over 600 reported DBPs to 209 for SAR assessment. The mechanism-based SAR analysis involved the comparison of an untested chemical with structurally related compounds for which carcinogenic activity is known. A prediction of carcinogenic potential was made by integration of all the available information with human expert intuition and judgment.

SAR predictions were made for 209 DBPs, and of these none were considered to be of high concern. There were 20 predicted to be of moderate or high-moderate concern. Of these, four were structural analogs of 3-chloro-4-(dichloromethyl)-5-hydroxy-2(5H)-furanone (MX). MX is a potent, direct-acting mutagenic DBP, however it is believed to occur at very low levels in drinking water and therefore these analogues were considered not likely to be of great

concern. Five other DBPs were halogenated alkanes, which will be controlled by existing and future THM regulations in the US. The other 11 DBPs (including halonitriles, haloketones, haloaldehyde, halonitro-alkane and dialdehyde) are considered the most suitable candidates for future carcinogenicity testing.

Analysis of the cytotoxicity and mutagenicity of drinking water disinfection by-products in *Salmonella typhimurium*.

Kargalioglu Y, McMillan BJ, Minear RA, Plewa MJ. Teratog Carcinog Mutagen (2002) **22**(2) p113-28.

This paper describes analysis of a select group of disinfection by-products (DBPs) for cytotoxicity and mutagenicity using a series of *Salmonella typhimurium* strains. The DBPs included: bromoform (BF), bromoacetic acid (BA), dibromoacetic acid (DBA), tribromoacetic acid (TCA), chloroform (CF), chloroacetic acid (CA), dichloroacetic acid (DCA), trichloroacetic acid (TCA), 3-chloro-4-(dichloromethyl) – 5-hydroxy-2[5H]-furanone (MX) and potassium bromate (KBrO₃).

A rank order for the cytotoxicity and mutagenicity of these DBPs was compared and the structure-function activity of these DBPs in relation to their cytotoxic and genotoxic potency was determined. The rank order of mutagenic potency adjusted with a cytotoxicity factor was MX>BA>EMS>DBA>DCA, with TBA, TCA, BF and CF found to be not mutagenic. A quantitative structure function analysis of the brominated acetic acids vs the chlorinated analogs of the haloacetic acids found that the brominated acetic acids had a higher mutagenic potency. BA was 150 times more mutagenic than CA. The mutagenic potency of haloacetic acids was inversely related to the number of halogen atoms. BA was 36 times more mutagenic than DBA.

Drinking water contaminants and adverse pregnancy outcomes: a review.

Bove F, Shim Y, Zeitz P. Environ Health Perspect (2002) **110**(Suppl 1) p61-74.

This article reviews the strengths and weaknesses of the current epidemiological evidence for the relationship between adverse birth outcomes and

exposure to chlorination disinfection by-products (DBPs) and chlorinated solvents such as trichloroethylene (TCE) in drinking water. A total of 14 studies on chlorination DBPs were reviewed and five studies on chlorinated solvents. The adverse birth outcomes examined were small for gestational age (SGA), low birth weight, preterm birth, birth defects, spontaneous abortions and foetal deaths. Most studies had significant limitations in exposure assessment and possible sources of bias that may have produced substantial inaccuracies in risk estimates and altered exposure-response trends.

There was moderate evidence found for associations with SGA, neural tube defects (NTDs) and spontaneous abortions in the studies of THMs and adverse birth outcomes. As fewer studies have been conducted on compounds other than THMs, the evidence for associations is weaker. However a relationship between excess NTDs and oral clefts and TCE-contaminated drinking water was found in two of the studies, and excess choanal atresia and excess cardiac defects and TCE-contaminated drinking water were each found in one study. These results require further investigation.

Cancer risk associated with household exposure to chloroform.

Levesque B, Ayotte P, Tardif R, Ferron L, Gingras S, Schlouch E, et al. *J Toxicol Environ Health* (2002) Part A. **65**(7) p489-502.

The objectives of this study were to measure exposure of male adults to chloroform under real-life conditions in houses in Quebec City region, taking into account inhalation, dermal and ingestion exposure. The cancer risk associated with this exposure was also estimated. Eighteen men from four municipalities in Quebec were included in the study. Subjects showered for 10 minutes, and exhaled breath was collected before, immediately after and 15 and 30 minutes after the shower. Indoor air samples were collected, and water chloroform concentrations were determined from a cold tap water sample as well from the shower water.

The median and mean chloroform concentrations measured in the cold water of the 18 participants

homes were 25.5 micrograms/L and 29 micrograms/L respectively. The mean chloroform concentration in air samples collected from the shower stall during the shower was 147 micrograms/m³ and the mean chloroform concentration in the shower water was 20.1 micrograms/m³. The mean chloroform alveolar air concentration immediately after the shower was 39.1 micrograms/m³ and 15 minutes later values were still high compared to the basal level, after 30 minutes values were almost back to base level. The only variable associated with chloroform internal dose due to showering was the air concentration in the shower stall during the shower.

A physiologically based pharmacokinetic (PBPK) model and a "threshold approach" was used to evaluate the carcinogenic risk resulting from exposure to chloroform during the showering and according to multiroute exposure scenarios. Based on the worst-case scenario, the highest concentration estimated in the liver in this study was 0.41 micrograms chloroform/kg of tissue. This is approximately 6000 times lower than the lowest concentration that did not increase the incidence of hepatic tumours in laboratory animals. Therefore for most Canadians who receive tap water from a municipal water treatment plant, the safety margin for cancer effects is substantial even when all likely exposure routes to chloroform are considered.

Distribution and determinants of trihalomethane concentrations in indoor swimming pools.

Chu, H. and M.J. Nieuwenhuijsen *Occup Environ Med* (2002) **59**(4) p243-7.

Chlorination is used as a major disinfectant of public swimming pools, when chlorine is added to water it reacts with organic matter such as skin scales and residuals from body care products to form various DBPs including trihalomethanes (THMs). This study estimated the concentrations of THMs in indoor swimming pools in London, the variability in these concentrations, and any correlation with other factors. Eight swimming pools were selected and water was sampled between 19 June 2000 and 14 July 2000. When the samples were collected the water and air temperature were recorded as well as pH, turbulence and the number of people in the pool.

Pool water samples were analysed for total organic content (TOC) and THMs.

A total of 44 pool samples were collected. The arithmetic mean TOC concentration of the swimming pools (6.3 mg/L) was higher than that of London tap water (2.3 mg/L). It was found that the concentrations of the THMs: chloroform, bromodichloromethane (BDCM), chlorodibromomethane (CDBM) and total trihalomethanes (TTHMs) had much greater variation within pools than between pools, whereas TOC had greater variation between pools. There was good correlation between TOC and TTHMs ($r=0.5$, $p<0.05$). There was a positive linear correlation found between water temperature and TTHMs ($r=0.5$, $p<0.01$). The number of people swimming in pools and concentrations of TTHMs and chloroform showed the strongest correlation ($r=0.7$, $p<0.01$).

The study confirmed that swimming pools may be a substantial contributor to THM exposure particularly via the dermal and inhalation routes, therefore assessment of exposure through swimming should be included in studies of the health effects of DBPs.

Drinking Water Treatment

The effect of drinking water treatment on the spatial heterogeneity of micro-organisms: implications for assessment of treatment efficiency and health risk.

Gale P, Pitchers R, Gray P. *Wat Res* (2002) **36**(6) p1640-8.

This study considered the effect of drinking water treatment on the spatial heterogeneity (or clustering) of five species of microorganisms at pilot scale. The water treatment process studied consisted of flocculation, followed by rapid gravity filtration and backwash of sand filter preceded by air scour. The microorganisms examined were: total coliform bacteria, total heterotrophic plate count bacteria and spores of aerobic spore-forming bacteria indigenous to raw water. Also *Bacillus subtilis* var *niger* spores and *Cryptosporidium parvum* oocysts were examined. Monitoring experiments to determine the

spatial heterogeneity using a 500L volume of raw water and a 500L volume of treated water were performed at four time points on the filter cycle during the 24h period when spiking was in progress. Two monitoring experiments were performed 20 and 25h after the spiking had been terminated.

Drinking water treatment was found to increase the spatial heterogeneity of aerobic spores and *B. subtilis* var *niger* spores, but not total coliform bacteria or plate count bacteria. *B. subtilis* var *niger* spores were recorded in single 'spot' samples of treated waters taken 20 and 25h after spiking was terminated. It was not possible to assess whether *C. parvum* oocysts were spatially heterogenic in treated water because few oocysts broke through treatment. There were differences in the removal ratios of the different species. *C. parvum* were removed about 40-fold more efficiently than *B. subtilis* var *niger* spores and about 500-fold more efficiently than aerobic spores.

The results found here have implications for monitoring and auditing at treatment works. It was found that audits based on single 100ml "spot" samples for spores tended to under-estimate the total numbers of spores in treated water relative to the total number of spores in raw waters, therefore leading to an over-estimation of spore removal. Also monitoring by taking "spot" samples tended to over-estimate removal of spores to a larger extent than the removal of coliforms. It can be concluded that there is no "ideal" surrogate for predicting the occurrence of microorganisms in treated water.

E. coli O157

A waterborne outbreak of Escherichia coli O157 : H7 infections and hemolytic uremic syndrome: Implications for rural water systems.

Olsen SJ, Miller G, Breuer T, Kennedy M, Higgins C, Walford J, et al. *Emerg Infect Dis* (2002) **8**(4) p370-5.

In late June in 1998, an increase in cases of bloody diarrhea was noticed by physicians near the town of Alpine, Wyoming (population 500). By early July, 14 people had been diagnosed with *Escherichia coli* O157:H7 infection. To determine the source of the

outbreak, an investigation was undertaken. Area physicians and health officials in neighbouring states were contacted to identify cases of illness. A cohort of people from outside Wyoming who had attended a large family reunion in Alpine on June 26-28 were interviewed. A cohort study of all residents of Alpine during July 13-16 was also conducted. Information was collected on symptoms, foods, tap water consumption and water filtration practices.

A total of 157 ill people from 15 states were identified, with *E. coli* 0157:H7 confirmed by culture in 71 cases. Four people were hospitalised with haemolytic uremic syndrome. There was a significant association between drinking unchlorinated water from the Alpine municipal water system and illness in each of the two cohort studies.

Environmental investigations showed the shallow spring supplying the town was vulnerable to surface water intrusion and contamination from deer and elk faeces, although *E. coli* 0157:H7 was not detected in animal faecal samples. Among people who were exposed to municipal water on the weekend of June 26 to 28, the attack rate was significantly lower for town residents than for visitors. The attack rate also decreased with increasing age among town residents who drank municipal water. These findings suggest that Alpine residents may have been previously exposed to *E. coli* 0157:H7 and may have acquired some immunity to symptomatic infection.

This outbreak confirms that small, unprotected and unchlorinated water systems can be a significant source of infection with *E. coli* 0157:H7 and other pathogens. Regulations need to be enforced more stringently and may need to be broadened in order to prevent illness from rural drinking water sources.

Gastrointestinal Illness

Risk factors in HIV-associated diarrhoeal disease: the role of drinking water, medication and immune status.

Eisenberg JNS, Wade TJ, Charles S, Vu M, Hubbard A, Wright CC, Levy D, Jensen P, Colford JM, Jr. *Epidemiol Infect* (2001) **128**(1) p73-81.

A cross-sectional survey of HIV-infected patients at the San Francisco Veterans Administration Medical Center was conducted between October 1998 and June 1999. The aim of the survey was to examine: the prevalence of diarrhoea, the degree to which drinking water habits were associated with gastrointestinal illness and the attributable risk of diarrhoea associated with medication risk.

Of a total of 226 HIV infected males in the study, 47% reported diarrhoea in the preceding 7 days. Drinking boiled or filtered water was not significantly associated with diarrhoea (OR=0.5 [0.2,1.6], and 1.2 [0.6,2.5] respectively). Drinking bottled water was associated with increased risk of having diarrhoea (OR=7.5 [2.1-27.1]). There was a significant association between CD4 count above 500 (measure of immune status) with decreased diarrhoea (OR = 0.4 [0.2,0.7]). For those taking medication with a low risk of diarrhoeal side effects, increase in CD4 count was protective against diarrhoea (OR=0.6 [0.5,0.9]). When those with high medication risk were compared to those with low medication risk, a 30% attributable risk of diarrhoea was estimated.

In this study there was awareness amongst participants that diarrhoeal disease may be transmitted via drinking water, however a significant portion of diarrhoea was found to be associated with other sources such as side effects of medication and not related to drinking water.

Legionella

Legionnaires' disease associated with habitual drinking of hot spring water.

Tominaga M, Aoki Y, Haraguchi S, Fukuoka M, Hayashi S, Tamesada M, Yabuuchi E, Nagasawa K. *Intern Med* (2001) **40**(10) p1064-7.

A male office worker in his fifties presented to a hospital in Japan with respiratory distress, fever, non-productive cough, dyspnea and myalgia of the trunk and extremities. The patient's symptoms were strongly suggestive of Legionnaire's disease, which was later confirmed. The patient had been purchasing water for nearly a year via a conduit to his home from a hot spring in the vicinity. The hot spring water was

used for drinking but not bathing, and the patient was frequently exposed to splashes of water when filling drinking vessels.

Genetic similarities between *Legionella pneumophila* isolates from the patient, the tap water and a hot tub at the spring led to the hypothesis that the illness had been contracted by aspiration of the hot spring water at home. The authors note that almost half of the hot springs surveyed nationwide in Japan in 1994 were contaminated by *Legionella* species, and domestic use of this water may represent a previously unrecognised exposure source.

Control of nosocomial Legionnaires' disease by keeping the circulating hot water temperature above 55 degrees C: experience from a 10-year surveillance programme in a district general hospital.

Darelid J, Lofgren S, Malmvall BE. *J Hosp Infect* (2002) **50**(3) p213-19.

An outbreak of *Legionella pneumophila* occurred in a 450-bed district hospital in Sweden with 31 nosocomial (hospital-acquired) cases diagnosed over a three month period in 1990/91. Raising the hospital's hot water tank temperature from 45C to 65C stopped the outbreak, however the bacteria were not eradicated from the hot water system. This increase in temperature was maintained during the following years and no chemical eradication measures were used in the hospital supply which received unchlorinated water from the municipal system.

A prospective surveillance program of all cases of nosocomial pneumonia in this district general hospital was undertaken to ascertain if raised hot water temperature was sufficient for long-term control of nosocomial Legionnaire's disease. The objective of this study was to determine the incidence of nosocomial pneumonia due to *L. pneumophila* serogroup 1 by using serology or urinary antigen detection as diagnostic tests.

The water temperature leaving the central hot water tank is checked once a week in the hospital and has been maintained at 65C, while water delivered at the

most distal taps was in the range of 56C to 61C. Hot water samples have been collected from selected taps and showers twice a year in all wards since 1992 and cultured for legionellae. A surveillance program began in 1992 in which all patients with nosocomial pneumonia requiring hospitalisation were reported. A serum sample was obtained on the day of registration in all reported cases (288) and six weeks after onset of symptoms in 68% (195/288) of cases from January 1992 to December 1997. From January 1998 to October 2000, urine for antigen detection was obtained on day of registration in 99% (77/78) of cases reported and a second sample was taken five days after in 87% of cases (68/78).

Of the 366 cases of nosocomial pneumonia recorded during the surveillance period, four cases met the criteria for infection with *L. pneumophila* serogroup 1. The incidence of nosocomial pneumonia due to *L. pneumophila* serogroup 1 during the surveillance period was therefore one per 26,000 admissions or about one new case every two years. The hot water samples revealed that all hospital buildings were colonized with *Legionellae* apart from the ground floor where the intensive care unit was. The median count of *L. pneumophila* serogroup 1 from 1992 to 2000 was 16 cfu/100mL as opposed to 600 cfu/100 mL during the outbreak. *L. pneumophila* serogroup 1 was isolated in 30 of the 251 cultured water samples during the monitoring period, and was found at least once in 9 of the 23 wards.

The results indicate that circulating hospital hot water above 55C is a safe and effective long-term measure to control nosocomial Legionnaire's disease in a district general hospital even though colonization of the water system with *Legionella* spp. is still occurring. Clinical surveillance is also important and frequent urinary antigen testing in nosocomial pneumonia patients should be undertaken.

Comment This hospital did not have an organ transplant program, therefore the potential risks for this class of patients cannot be assessed. Organ transplant recipients are at increased risk of *Legionella* infection due to suppressed cellular immunity.

Leptospirosis**Leptospirosis, water sports, and chemoprophylaxis.**

Haake DA, Dundoo M, Cader R, Kubak BM, Hartskeerl RA, Sejvar JJ, et al. Clin Infect Dis (2002) **34**(9) E40-E43.

Leptospirosis is a bacterial infection which occurs in humans and animals, and can be fatal on a small percentage of cases. The causative organisms, leptospire, are present in the urine of infected individuals and may survive for extended periods in aqueous environments after excretion. Infection generally occurs by contact with contaminated water, mud or soil via skin abrasions, exposed mucous membranes or ingestion. The disease is more common in tropical regions especially after periods of heavy rainfall. This paper describes two cases of leptospirosis following the Eco-Challenge Sabah 2000 competition in Malaysian Borneo, and notes that at least 68 cases were reported among the 304 competitors in this event.

To prevent leptospirosis, protective clothing, especially footwear should be worn, and measures should be taken to avoid dermal cuts and abrasions. Travellers in tropical regions should avoid drinking and submerging in surface water. A number of studies have suggested that chemoprophylaxis with doxycycline may be effective in preventing leptospirosis. Given the growing popularity of adventure travel, physicians need to be aware of the risk factors for leptospirosis and be familiar with diagnosis, prevention and treatment.

Wastewater Contaminants**Pharmaceuticals, hormones, and other organic wastewater contaminants in US streams, 1999-2000: A national reconnaissance.**

Kolpin DW, Furlong ET, Meyer MT, Thurman EM, Zaugg SD, Barber LB, Buxton HT. Environ Sci Technol (2002) **36**(6) p1202-11.

During 1999 and 2000 the US Geological Survey used five newly developed analytical methods to measure concentrations of 95 organic wastewater

contaminants (OWCs) in water samples from 139 streams across the 30 states. The objective of the study was to determine if OWCs are entering US streams and to estimate the extent of their co-occurrence in susceptible waters. The OWCs studied included antibiotics, other prescription drugs, nonprescription drugs, steroids, reproductive hormones, personal care products, products of oil use and combustion, and other extensively used chemicals. The streams sampled were selected because they are in areas considered susceptible to contamination from human, industrial and agricultural wastewater. Each stream site was sampled once during the study period.

One or more of the OWCs was found in 80% of the 139 streams sampled, and 82 out of the 95 OWCs were detected at least once during the study. The measured concentrations of OWCs were generally low with few compounds exceeding the drinking water guidelines, health advisories, or aquatic-life criteria. However such guidelines or criteria have not been established for many OWCs. The most commonly identified compounds were coprostanol (faecal steroid), cholesterol (plant and animal steroid), *N,N*-diethyltoluamide (insect repellent), caffeine, triclosan (antimicrobial disinfectant), tri (2-chloroethy) phosphate (fire retardant) and 4-nonylphenol (nonionic detergent metabolite). Seventy-five percent of the streams had more than one OWC detected with a median value of seven for these streams. One sample had 38 compounds detected. There is little known about the additive or synergistic effects of mixtures of OWCs.

The results of this study show that measurable quantities of OWCs occur in streams throughout the US and therefore such compounds must have survived wastewater treatment and biodegradation. Further studies are needed to determine the effects low-level exposure to pharmaceuticals and other OWCs will have on humans, plants and animals.

Comment The authors note that many of the detections were for a method using unfiltered water samples, thus the OWCs may have been associated with particulate matter rather than dissolved in the aqueous phase.

Additional Articles

Detection and enumeration of coliforms in drinking water: current methods and emerging approaches [Review].

Rompere A, Servais P, Baudart J, de-Roubin MR, Laurent P. *J Microbiol Methods* (2002) **49**(1) p31-54.

Detection of excess arsenic-related cancer risks.

Frost F, Craun G, Brown KG. *Environ Health Perspect* (2002) **110**(1) pA12-A13.

Arsenic poisoning in groundwater - Health risk and geochemical sources in Bangladesh.

Anawar HM, Akai J, Mostofa KMG, Safiullah S, Tareq SM. *Environ Int* (2002) **27**(7) p597-604.

U.S. drinking water challenges in the twenty-first century.

Levin RB, Epstein PR, Ford TE, Harrington W, Olson E, Reichard EG. *Environ Health Perspect* (2002) **110**(Suppl 1) p43-52.

Implications of fluoride - An endless uncertainty.

Pillai KS, Stanley VA. *J Environ Biol* (2002) **23**(1) p81-7.

The effect of heating against *Cryptosporidium* oocysts.

Fujino T, Matsui T, Kobayashi F, Haruki K, Yoshino Y, Kajima J, et al. *J Vet Med Sci* (2002) **64**(3) p199-200.

Assessing exposure in epidemiologic studies to disinfection by-products in drinking water: Report from an international workshop [Review]

Arbuckle TE, Hrudey SE, Krasner SW et al. *Environmental Health Perspectives*. **110**(Suppl 1):53-60, 2002

A waterborne outbreak of Norwalk-like virus in a winter holiday resort in Sweden

Carriqué-Mas JJ, Andersson Y, Hedlund K-O and Giesecke J *Eurosurveillance Weekly*: Thursday 18 April 2002. Volume 6, Issue 16.

Disclaimer

Whilst every effort is made to reliably report the data and comments from the journal articles reviewed, no responsibility is taken for the accuracy of articles appearing in Health Stream, and readers are advised to refer to the original papers for full details of the research

Health Stream is the quarterly newsletter of Program 1 *Health and Aesthetics* of the CRC for Water Quality and Treatment. Health Stream provides information on topical issues in health research which are of particular relevance to the water industry, news and updates on the recent literature.

The CRC for Water Quality and Treatment also produces the quarterly newsletter **Water Quality News** featuring current affairs, highlights from all research programs of the CRCWQT, and information about other CRCWQT activities.

Both newsletters are available free of charge to the water industry, public health professionals and others with an interest in water quality issues. Electronic versions of the newsletters and a searchable archive of Health Stream articles are available on the Web page of the CRCWQT.

To be placed on the Health Stream or Water Quality News mailing lists please contact:

Pam Lightbody
Epidemiology and Preventive Medicine
Central & Eastern Clinical School, Alfred Hospital
Prahran VIC 3181, AUSTRALIA

Phone +61 3 9903 0592
Fax +61 3 9903 0576
Email pam.lightbody@med.monash.edu.au

Established and supported under the Australian Government's Cooperative Research Centres Program