# Health Stream

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## *In this Issue:*




Editor Martha Sinclair
Assistant Editor Pam Lightbody


## CRCWQT Internet Address:
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## Workshop Report: Effective Drinking Water Quality Management

Bonn, Germany 9-11 February 2004.

*Report by Dr Daniel Deere, CRC for Water Quality and Treatment*

The International Water Association (IWA) recently held a workshop in Bonn to develop what was described as "The Bonn Charter: A 21st Century Framework for Assuring Drinking-water Quality". The meeting, hosted by the German Association on Gas and Water, was opened by IWA President Michael Rouse and organised by Dr Bob Breach of Severn Trent Water and Dr Andrew Speers of IWA. The meeting (referred to here as Bonn II) followed on from one held in the same location in 2001 (Bonn I). The following report summarises the discussion and outcomes of the two events.

**Bonn I**

Bonn I was entitled "Alternative Approaches to Drinking Water Quality Assurance for the 21st Century" and was convened in response to concerns in the drinking-water sector over the so-called "contaminant-by-contaminant approach" to drinking-water regulation. There were concerns about the costs, difficulties, (in some cases impossibility), of detecting some of the hazards for which regulation was desired at low guideline value concentrations. In addition, there was an understanding that such regulation is not necessarily preventive and might only alert water suppliers to contamination after consumption had occurred. The concentrations of hazards in water supplies can vary rapidly, due to source water, treatment and distribution system phenomena. Furthermore, many of the reported waterborne disease outbreaks have arisen from events that might have been missed even by relatively

intensive monitoring since they involved sporadic failures of barriers combined with other causal events. Despite this, regulatory models were geared to the addition of an ever-growing list of chemical and microbiological hazards. In contrast, risk-based approaches had been proposed that appeared to offer a preventive alternative (1).

At Bonn I, 33 delegates from nine countries (Australia, Belgium, Canada, Denmark, France, Germany, Netherlands, UK and US) with diverse roles (utility, association, regulators) attended the two-day event. The primary objective was to devise an alternative regulatory approach for drinking water which included more quality assurance principles.

Much of the support for the Bonn I meeting came from the US, Canada and UK who had seen their Australian and New Zealand counterparts adopt a divergent water quality regulatory approach, breaking a long tradition of similarity in drinking-water regulation between the Anglophone nations. The Australians had developed the "Framework for the Management of Drinking Water Quality" (2) and the New Zealanders, the "Public Health Risk Management Plans" (3). Both provided examples of alternative regulatory models in which a risk-based approach to water quality management ("input controls"), coupled with targeted water quality monitoring ("output controls") were captured within a broader water quality management framework that included issues such as stakeholder and community involvement and management commitment.

At Bonn I "three layers of control" were agreed as follows:

- Responsibility and Institutional Arrangements were seen as in need of proper definition:
  - Critical to have clarity of responsibility from source to tap;
  - Role of many different stakeholders have to be clear; and
  - Must have proper legal framework with independent regulation.
- Regulation of contaminants involving their direct monitoring was defined as "output control":
  - Transparency of process is vital;
  - Output control values will continue to play a key role but with a greater emphasis on the complementary use of input control systems;
  - The number of parameters for which statutory output standards are set should be minimised;
  - The use of scientifically valid indicator parameters should be encouraged;
  - Operational control parameters play a key role in monitoring the effectiveness of treatment barriers;
  - There should be flexibility to account for local circumstances.
- A quality assurance concept was defined as "input control" made up of:
  - System wide risk based assessment from catchment to tap;
  - Identification of most effective control points;
  - Effective operational and management plans to deal with normal and abnormal operating conditions;
  - Critical to have measures to assess the effectiveness of controls; and
  - Independent 3rd party verification essential but not so as to conflict with management responsibility.

**Bonn II**

It was noted that since Bonn I a number of important and relevant events had taken place:

- The Australian Framework had been finalised as part of the latest rolling revision to the Australian Drinking Water Guidelines and was forming the basis of contemporary state drinking-water legislation (4);
- The New Zealand Public Health Risk Management Plans were being implemented under their national legislation; and
- The World Health Organization Water Safety Plans had been finalised (5) and formed the basis of the 3rd Edition of the Guidelines for Drinking-water Quality.

These examples were cited as working case studies of what was endorsed as part of the Bonn I framework, demonstrating that it was fundamentally a workable model. In addition, the popularity of events such as the hazard analysis and critical control point (HACCP) in water quality management meetings held in Berlin (6), or planned for Ann Arbor (7), attested to the interest in these types of approaches.

These experiences and events were considered to have provided the practical experience required to re-examine the findings of Bonn I. The purpose of Bonn II was, therefore, to review the findings from Bonn I and to develop a revised Charter. The meeting involved keynote presentations and representation from several regions including:

- European: a European Union (EU) delegate presenting with the European Union of National Associations of Water Suppliers and Waste Water Services (EUREAU) being present and the German Association on Gas and Water (DVGW) being present and hosting the meeting;
- North American: an American Water Works Association Research Foundation (AwwaRF) delegate presenting with the US Environmental Protection Agency (EPA) and Canadian Water and Wastewater Association (CWWA) being present;
- Australian: a Cooperative Research Centre for Water Quality and Treatment (CRCWQT) delegate presenting with Water Services Association of Australia (WSAA) being present; and
- International: both WHO and IWA presenting with the latter body organising the meeting.

A series of intensive workshops and presentations were held in both plenary and breakout groups over two-and-a-half days, culminating in a draft revised Charter (this word being used in preference to Framework). Each part of the Charter was considered, beginning with the overall concept, moving through terminology and then working in detail on the wording.

The goal of the Bonn II Charter was drafted as being the supply of "good safe drinking water which has the trust of consumers". A set of principles were developed, which included emphasising the importance of catchment to tap risk assessment and management plans, and a revised terminology was developed. Like the Bonn I output, the Bonn II Charter was structured to involve "three layers of control" which were:

- "stakeholder roles and responsibilities";
- "drinking water quality management plans" (in place of the phrase "input controls" used previously); and
- "verification of drinking water quality" (in place of the phrase "output controls" used previously).

Implementation and roll-out plans were developed for the Charter at the Bonn II meeting. It is intended that the revised Charter will be circulated widely over the following months, then be finalised and launched at the IWA biennial meeting in Marrakech, September 2004.

*References*

1) Deere, D., Stevens, M., Davison, A., Helm, G. and Dufour, A (2001) Management Strategies. In: Water Quality: Guidelines, Standards and Health. Assessment of risk and risk management for water-related infectious disease. Fewtrell L. and Bartram J. (eds). IWA Publishing, London. ISBN 1 900222 28 0.

2) NHMRC (2001) Australian Drinking Water Guidelines and Framework for Management of Drinking Water Quality. National Health and Medical Research Council. http://www.health.gov.au/nhmrc/publications/synopses/eh19syn.htm. Accessed 9 March 2004.

3) MoH (2001) Public Health Risk Management Plan Guides for Drinking Water Supplies. New Zealand Ministry of Health. http://www.moh.govt.nz/moh.nsf/wpg_index/Publications-Public+Health+Risk+Management+Plan+Guides+for+Drinking+Water+Supplies. Accessed 9 March 2004.

4) GoV (2003) Safe Drinking Water Act 2003. Act No. 46/2003. Government of Victoria. http://www.dms.dpc.vic.gov.au/sb/2003_Act/A01263.html Accessed 9 March 2004.

5) Davison, A., Howard, G., Stevens, M., Callan, P., Kirby, R., Deere, D. and Bartram, J. (2003) Water Safety Plans. Protection of the Human Environment. Water, Sanitation and Health. WHO/SDE/WSH/02.09.

6) WHO (2003) Specialist Conference on Water Safety – Risk Management Strategies for Drinking-water. World Health Organization, Berlin, 28-30 April.

7) NSF (2004) Risk Management Strategies for Drinking Water Utilities: The Role of HACCP, Management Systems and Water Safety Plans, National Sanitation Foundation and World Health Organization, Ann Arbor, Michigan, 4-5 May.

## Setback for Bangladesh Arsenic Claim

The British Court of Appeal has overturned a High Court decision made in May last year to allow a case by a Bangladeshi claimant against the UK National Environment Research Council (NERC) to proceed to trial (1). The claimant alleged that the British Geological Survey (BGS, a department of NERC) showed negligence by failing to test for arsenic during a 1992 survey of groundwater supplies in Bangladesh. The use of groundwater as a drinking water source was widely promoted by aid agencies in the 1970s and 1980s to reduce risks of infectious diseases from contaminated surface water supplies. However by the late 1990s, cases of chronic poisoning from arsenic contaminated groundwater had become evident in many areas of Bangladesh.

After the initial action was lodged in the High Court in August 2002 by lawyers acting on behalf of the Bangladeshi claimant, the NERC made an application for the claim to be struck out without proceeding to trial, on the grounds that there were no reasonable grounds for bringing the claim. Alternatively, NERC asked the court to make a summary judgement rather than allowing the case to go to trial, on the basis that the claimant had no real prospects of success with the claim. The NERC application was dismissed on 8 May 2003, permitting the case to proceed to trial, however NERC subsequently appealed against the ruling.

The Court of Appeal delivered its verdict on 20 February 2004, ruling that the claim could not proceed to trial as it was bound to fail. The Court concluded that the Defendant (NERC), did not owe a duty of care to the Claimant and the class which the Claimant represents, and that it would not be fair, just and reasonable to impose such a duty. It is reported that the Claimants lawyers may now appeal against this decision, with the matter possibly being decided by the House of Lords.

(1) See Health Stream Issue 30 (June 2003) for a report on the earlier High Court decision to allow the case to proceed to trial.

## Leukemia Panel Final Report

The Expert Panel appointed to investigate the occurrence of excess cases of childhood leukemia in Churchill County, Nevada has delivered its final report and recommendations. The Expert Panel was appointed in February 2001, following the identification of a cluster of 16 leukemia cases in and around the town of Fallon (1). The panel initially reviewed the investigations already undertaken by the Nevada State Health Department, and made a number of recommendations regarding case finding and characterisation, further investigation of environmental exposures, and research studies. The final report reviews the outcomes of these investigations over the last three years.

Completeness of case finding A number of supplementary information sources were used in addition to the Nevada Central Cancer Registry to ensure that no cases of leukemia were missed. Concerns had been raised about the completeness of data held by the registry as in 2001 it had not yet received certification for quality control and registry procedures. The Expert Panel was satisfied from its investigations that since 1997 all children living in Churchill county when diagnosed with leukemia have been identified.

Clinically relevant disease biomarkers in cases The panel recommended that available medical records and biological samples be used to examine biomarkers in the affected children. Information to distinguish between T-cell and precursor-B cell forms of leukemia was available for 15 children, and the ratio was similar to that usually seen among childhood leukemia cases. No conclusions could be drawn about biomarkers or chromosomal abnormalities that may have been present prior to cancer treatment, as there were no biological samples taken or chromosome testing performed for 11 of the 14 children.

Environmental exposures unique to the community Extensive investigations of environmental exposures in and around Fallon, showed that exposures to arsenic and tungsten in drinking water supplies were higher than the US population average. Prolonged

exposure to arsenic is known to cause skin cancers and probably cancer of some internal organs (eg the lung and bladder), but it has not been linked to leukemia in either adults or children. Toxicological data on tungsten are limited but do not suggest that it is a human carcinogen. No significant differences in tungsten exposure were found between cancer cases and healthy controls in Fallon, and there was no indication that tungsten exposure levels had changed over time in the community.

In order to determine whether the exposure of Churchill County residents to tungsten was unique, a survey of three other Nevada towns was carried out. Two of these communities had similar hydro-geological characteristics to Fallon, and also had a history of tungsten mining. The third community had different hydrogeological characteristics and had no tungsten mines in the vicinity. Levels of tungsten in tap water and in urine samples from residents were measured. Although only two of the three communities had significant concentrations of tungsten in tap water, the geometric mean urinary tungsten levels were high in all three populations (above the 95th percentile in the national NHANES study). The reasons for the high urinary levels in the population with low levels of tungsten in drinking water are unknown, however the study demonstrated that tungsten exposure levels in Fallon were not unusual among Nevada communities.

The environmental investigation specifically included an assessment of potential exposure to jet fuel from the nearby naval base, but no significant exposures of the population to the fuel or other harmful environmental contaminants were identified.

Characterisation of population changes Some clusters of childhood leukemia appear to be associated with a sudden influx of people into a community that was previously fairly isolated. It has been hypothesised that one or more infectious agents from the incoming population may spread rapidly through the susceptible population of children and that this may in some way trigger the development of leukemia in some children.

The naval base near Fallon was a source of population change but the number of permanent military personnel remained fairly constant in the years prior to the cancer cluster. However there was a rapid increase in the number of personnel assigned for short-term training between 1993 and 2000. The Expert Panel was unable to reach a conclusion on whether this may have triggered the cancer cluster.

Genetic factors Genetic testing of cases and controls to determine whether there are differences that may relate to susceptibility to leukemia is currently being conducted by the Centers for Disease Control and Prevention (CDC).

The panel made a number of recommendations regarding the Fallon area:

- the Nevada State Health Departments (NSHD) should continue surveillance for childhood leukemia cases
- consideration should be given to collecting biological samples from any newly diagnosed cases (subject to appropriate ethical approval)
- unless compelling new information arises, there should be no further environmental or population sampling in the Fallon area in connection with the leukemia cluster
- efforts should be made to reduce arsenic exposure from private drinking water supplies (treatment of the municipal supply is already planned)
- NSHD and CDC should determine whether existing biological samples from cancer cases and controls can be made available for future research.

Recommendations were also made about future planning and coordination of research into childhood cancer clusters. CDC has just commenced investigation of another childhood leukemia cluster of 12 cases in Sierra Vista, Arizona. In response to the Fallon investigation, the US National Toxicology Program has initiated a series of studies to assess the toxicological properties of tungsten. The research program will take several years to complete.

(1) See Health Stream Issue 29 (March 2003) for a report on the investigation of the Nevada cancer cluster.

## Australian Drinking Water Guidelines Update

Australian Drinking Water Guidelines Revision

More than one year after the National Health and Medical Research Council (NHMRC) approved revisions to the Australian Drinking Water Guidelines incorporating the Framework for Management of Drinking Water Quality, the final document has still not been published.

The revised ADWG was approved by the NHMRC in April 2003, and then forwarded to the National Resource Management Ministerial Council for endorsement. The document was endorsed by the relevant agencies in all states and territories except one by August 2003. At the time of going to press, the state of New South Wales has still not completed the endorsement process despite several months of intensive lobbying by peak water industry bodies and many concerned individuals.

This publication is the culmination of over five years of collaborative work by stakeholders in the Australia industry to develop a preventive risk management approach to the operation of drinking water supplies. Australia has been recognised internationally as a pioneer in this new approach to water quality regulation, and it is both disappointing and frustrating to all those involved in the development process and more broadly in the water industry and regulatory areas, that official publication has been delayed for such a prolonged period of time.

Despite the publication delay, the Framework is being adopted by many water authorities across Australia, and has been incorporated into the Safe Drinking Water Act (2003) in Victoria. Several members of the Water Services Association of Australia have structured their most recent water quality reports to align with the twelve elements of the Framework, demonstrating their commitment to this approach and progress on implementation.

Working Party on Rural and Remote Water Quality

NHMRC has formed a Steering Group and Working Party to facilitate adoption of the ADWG Framework in small water supplies. The Working Party will develop a series of risk-based Model Drinking Water Quality Management Plans which will:

- be applicable to small rural, remote and indigenous communities
- address a range of drinking water supply scenarios including source type, community size, treatment methods and distribution infrastructure
- provide guidance on the development of risk assessment /management plans for small communities.

The Steering Group will oversee this work and undertake extensive public consultation to ensure the applicability of the Management Plans and to ensure that cross-cultural aspects have been taken into consideration. The group will also develop strategies for dissemination, engagement, capacity building and implementation. The development process is likely to include an international conference in early 2005, and the work plan is to be completed by December 2005.

## Risk Analysis of Outbreaks

Canadian researchers have analysed the Walkerton and Battleford waterborne disease outbreaks using a theoretical framework for risk management, and have identified common governmental and regulatory factors that contributed to the outbreaks (1). The risk management framework used for the analysis has two components:

- a structural hierarchy describing the various "actors" (individuals and organisations) involved in a complex sociotechnical system
- the dynamic forces that can cause such a system to modify its structure and behaviour over time

The structural hierarchy has six levels:

- Work - the behaviour associated with the process being controlled.
- Staff - the activities of individual staff members that are responsible for interacting directly with the process being controlled
- Management - the activities of the management that supervise the staff.
- Company - the activities of the company as a whole.

- Regulators/ Associations - the activities of the regulators or associations responsible for monitoring activities of companies in the sector
- Government - the activities of civil servants and elected individuals who are responsible for setting public policy.

In order for the system to operate and be monitored correctly, decisions must be propagated downwards through the management hierarchy, and information must be propagated upwards to provide feedback that influences future decisions.

The dynamic forces acting on the system consist of financial pressures to contain or reduce economic costs, and psychological pressures that push the actors to work in a more mentally or physically efficient manner. The combination of these forces causes gradual changes in the way people perform their jobs, which may eventually lead them to cross the boundary defined by official work practices and approach the boundary of safety.

This model illustrates how safety can be compromised by lack of communication between levels of the hierarchy, and failure of people on one level to understand how their decisions affect the other levels of the system. It also explains how work practices can slowly deteriorate without the effect on safety being immediately apparent. Accidents in such a system do not usually arise from a totally unprecedented action or event but from a slow erosion of safety margins until the weakened system is challenged by a combination of circumstances that overwhelm it.

The discussion of the Walkerton and Battleford outbreaks contains a number of errors and displays misunderstanding of some aspects of water treatment, however overall the analysis provides some useful insights into the common organisational and behavioural factors that may contribute to waterborne outbreaks or accidents in other complex systems.

1) Sociotechnical systems, risk management, and public health: comparing the North Battleford and Walkerton outbreaks. Woo DM and Vicente KJ (2003) Reliability Engineering and System Safety **80** p253-269.

# News Items

**Hoax embarrasses California city councillors**

City councillors in the Californian town of Aliso Viejo have been embarrassed by the revelation that they were fooled by a hoax website about the dangerous properties of "dihydrogen monoxide", and had been about to debate a motion to ban the substance from their city.

Dihydrogen monoxide - commonly known as water - is described on the website as:

- the major component of acid rain,
- contributing to the greenhouse effect and erosion of landscapes,
- accelerating corrosion and rusting of metals,
- decreasing the effectiveness of vehicle brakes,
- being present in the tumours of cancer patients,
- capable of causing severe burns,
- causing death by accidental inhalation, and severe tissue damage by prolonged contact with the solid form of the compound.
- being found in almost every stream lake and reservoir in the US, and even in Antarctic ice.

According to press reports, the incident was attributed to an over-zealous council paralegal employee who was fooled by the official looking spoof website of the "Dihydrogen Monoxide Research Division" (http://www.dhmo.org/).

The hoax is believed to have originated from the science fair project of a 14 year-old US junior high school student in 1997. The student presented fifty of his classmates with a report on the hazards of dihydrogen monoxide then asked what should be done about it. Only one student recognised the substance for what it was, while forty-three said it should be banned and six were undecided.

**Chlorine gloves for microbial safety**

A US company is planning to market disposable gloves which emit chlorine dioxide as a measure to reduce transmission of pathogens in the healthcare and food industries. The vinyl or polyethylene gloves contain microspheres of chemicals which when combined produce chlorine dioxide. The chemical release is triggered by light, so that the microbiocidal

effects of the gloves are not activated until they are worn. Chlorine dioxide production continues for up to four hours, and tests have shown they produce a 2-log reduction in bacterial counts within one minute of contact. The gloves, which will cost about 30% more than conventional products, are expected to be on the market within a year.

**Bottled water bromate contamination**

The Coca-Cola company has withdrawn its bottled water brand Dasani from the UK and postponed the launch of the product in several other European countries following the detection of bromate in UK stocks of the water at levels exceeding regulatory limits. The Dasani brand is marketed in the US and several other countries, and in most cases is prepared by filtration and treatment of municipal tap water. About 500,00 bottles of water were recalled in the UK when testing showed bromate levels to be at or in exceedance of the limit of 10 ppb.

**Fluid advice questioned**

Australian researchers have challenged the long held wisdom that people suffering from respiratory infections should drink plenty of fluids. In a brief report in the 28 February edition of the British Medical Journal, they reviewed published literature on the issue but found little systematic research. There were some reports of hyponatremia (low sodium levels in the blood) in patients with respiratory infection, although no specific evidence relating this to overhydration. The authors advocated caution in applying the traditional advice, particularly to patients with lower respiratory tract (pneumonia).

The popular press interpretation of the findings produced some alarmist headlines warning of dangers from drinking too much fluid when suffering from colds and flu. The publication also provoked a mixed response from BMJ readers with several pointing out that hospitalised patients with pneumonia were not comparable to people in the community with common mild infections of the upper respiratory tract, and that hyponatremia could occur by mechanisms other than overhydration. However others agreed that cases of hyponatremia were sometimes provoked by excess hydration in response to medical advice to "drink plenty of fluids".

# From the Literature

***Web-bonus articles***

Summaries of these additional articles are available in the web page version of Health Stream and included in the searchable archive at:

www.waterquality.crc.org.au

**Identifying US populations for the study of health effects related to drinking water arsenic.**
Frost F J, Muller T, Petersen H V, Thomson B, Tollestrup K. *J Expo Anal Environ Epidemiol* 2003;**13** (3):231-9.

**Arsenic Exposure from Drinking Water and Birth Weight**.
Hopenhayn C, Ferreccio C, Browning SR, Huang B, *et al. Epidemiology* 2003 **14**:593-602

**Environmental exposure, chlorinated drinking water, and bladder cancer.**
Goebell PJ, Villanueva CM, Rettenmeier AW, Rubben J, Kogevinas M. *World J Urology* 2004 **21**:424-32

**An outbreak of Vibrio cholerae 01 infections on Ebeye Island, Republic of the Marshall Islands, associated with use of adequately chlorinated water source.**
Beatty ME, Jack T, Sivapalasingam S, Yao SS, Paul I, *et al.. Clin Infect Dis* 2004 **38**:1-9

**Control of Cryptosporidium with wastewater treatment to prevent its proliferation in the water cycle.**
Suwa M, Suzuki Y. *Wat Sci Technol* 2003;**47** (9):45-9.

**Distribution and risk assessment of fluoride in drinking water in the west plain region of Jilin province, China.**
Zhang B, Hong M, Zhao YS, Lin XY, Zhang XL, Dong J. *Environ Geochem Health* 2003 **25**:421-31

**Incidence of gastroenteritis in Norway--a population-based survey.**
Kuusi M, Aavitsland P, Gondrosen B, Kapperud G. *Epidemiol Infect* 2003;**131** (1):591-7.

**The influence of calcium and magnesium in drinking water and diet on cardiovascular risk factors in individuals living in hard and soft water areas with differences in cardiovascular mortality.**
Nerbrand C, Agreus L, Lenner R A, Nyberg P, Svardsudd K. *BMC Public Health* 2003;**3**:1-24.

**Emerging genotype (GGIIb) of norovirus in drinking water, Sweden.**
Nygard K, Torven M, Ancker C*, et al. Emerg Infect Dis* 2003;**9** (12):1548-52.

**Drinking water quality in the Ethiopian section of the East African Rift Valley I--data and health aspects.**
Reimann C, Bjorvatn K, Frengstad B *et al.. Sci Total Environ* 2003;**311** (1-3):65-80.

Acanthamoeba

**Health effects of Acanthamoeba spp. and its potential for waterborne transmission.**
Nwachuku N, Gerba C P. *Rev Environ Contam Toxicol* 2004;**180**:93-131.

*Acanthamoeba* spp. are protozoa found commonly in water and soil. This review assesses the health effects of *Acanthamoeba* and the significance of water in its transmission. *Acanthamoeba* are capable of living free in nature and as pathogens in a host. *Acanthamoeba* feed on bacteria in the environment by trapping them in its cytoplasm. Some species of bacteria can grow and reproduce within the cytoplasm and become symbionts. *Acanthamoeba* may be carriers of *Legionella* species and under natural conditions these protozoa are the main means of proliferation of these bacteria. *Acanthamoeba* are abundant in the environment and have been found in surface waters, occasionally in marine water and sediments, in tapwater, in bottled water, swimming pools and spas, sewage and biosolids, animal wastes and air, dust and soil.

The two most common illnesses associated with *Acanthamoeba* spp. are *Acanthamoeba* keratitis (an eye infection) and granulomatous amoebic encephalitis (GAE). Keratitis occurs mainly in otherwise healthy people with known risk factors being wearing contact lenses, exposure to contaminated water or physical injury to the eye. Symptoms include pain and the formation of a whitish halo or ring infiltrate around the periphery of the cornea. If untreated, the infection can rapidly lead to scarring of the cornea and loss of vision. Two studies have found tapwater washing of lens cases to be a source of *Acanthamoeba* contamination of contact lenses. Also contact lens wearers that are exposed to hot tubs or natural springs are at risk of developing the illness. The pathogenicity of *Acanthamoeba* seems to be related to certain strains and low levels of IgA antibodies in the tears of infected individuals.

GAE is an opportunistic infection that occurs mainly in immunodeficient individuals. It is a chronic progressive disease of the central nervous system with chronic skin infections also being reported. The protozoa are thought to enter the bloodstream, probably via the nose, lungs or breaks in the skin following injury or trauma and then proceed to affect various organs via blood vessels. The pathogenesis of GAE is not well understood and is complex. Studies in mice have shown it is possible to immunise animals against *Acanthamoeba* meningoencephalitis. The immune response of the host is a significant risk factor in GAE infection.

This review did not identify any studies on the resistance of *Acanthamoeba* cysts or trophozoites to drinking water treatment and disinfection. Given the large size of the organism they should be easily removed by filtration. *Acanthamoeba* cysts are very resistant to chlorine, bromide and iodine inactivation as well as ultraviolet light. The trophozoites (active growing form) are much more sensitive to chlorine and other disinfectants used in drinking water treatment. They are however more resistant than bacteria. The survival of *Legionella pneumophila* when it is found growing within *A. castellanii* may be enhanced by the resistance of *A. castellanii* to chlorine. This added resistance may play a large role in the survival of this bacteria and in its ecology and persistence in the distribution systems of cooling towers and hot tubs and other environments.

Dose response experiments in animals suggest that at least 1000 trophozoites are necessary to cause *Acanthamoeba* eye infection. *Acanthamoeba* infection in contact lens wearers can be eliminated by proper care of the lens by avoiding contact with tapwater and proper disinfection of lenses and the solutions which they contact. The potential risk of transmission of *Legionella pneumophila* and *Mycobacterium avium* via drinking water due to their enhanced resistance to disinfectants when they are growing within *Acanthamoeba* may be reduced by providing an unsuitable habitat for *Acanthamoeba.* The number of bacteria on which *Acanthamoeba* can feed can be reduced by low organic matter and disinfectant residuals. One study has suggested that there is an increased risk of *Acanthamoeba* keratitis in municipal water supplies which have become contaminated. There also seems to be a relationship

between seasonal distribution of keratitis and abundance of *Acanthamoeba* in surface waters.

For risk assessment purposes, more information is required on the occurrence or types of *Acanthamoeba* in tapwater in the U.S. Information on the type of water treatment or the level of residual chlorine is missing from published work on amoebal presence in tapwater. Also assessment of the pathogenicity of *Acanthamoeba* in tap water by cell culture and molecular methods would be of use. More information is also required on the role of *Acanthamoeba* spp. as potential vectors for bacterial infections from water sources.

Arsenic

**P53 alterations in bladder tumors from arsenic and tobacco exposed patients.**
Moore L E, Smith A H, Eng C*, et al. Carcinogenesis* 2003;**24** (11):1785-91.

In most human cancers including bladder cancer, inactivation of the *p53* tumour suppressor gene is found. Some small studies of bladder and skin tumours have suggested the possibility of arsenic-specific mutational patterns in the *p53* gene. A case-control study was undertaken to compare *p53* mutations in 147 bladder tumours from patients in Argentina and Chile that reported ever or never smoking tobacco and patients exposed to various levels of arsenic in drinking water. P53 alterations were considered in relation to the patients age, gender and tumour stage and grade.

Cases came from two bladder cancer case-control studies conducted in Argentina and Chile. Cases were divided into ever or never smokers and then by pack years of tobacco exposure. Arsenic exposure in Argentina was calculated from water samples from the study area. In Chile, historic data on arsenic concentrations in drinking water from 1950 to 1994 was used. Cases were divided into four categories based on establishing the five years with the highest concentration of arsenic in each participant's drinking water during the period 5-40 years prior to bladder cancer diagnosis. Group 1 was non-detectable to less than 10 micrograms/L (*n*=50); group 2, 10-99 micrograms/L (*n*=31); group 3, 100-299 micrograms/L (*n*=35) and group 4, 300 micrograms/L or higher (*n*= 30). P53 alterations in bladder cancer tissue were assessed using DNA sequence and immunohistochemical (IHC) analysis.

The occurrence of tumours with *p53* mutations and those with positive IHC staining increased significantly with both stage and grade of tumour. There were no significant associations with *p53* mutations or P53 positive IHC staining found for age, gender, tobacco and arsenic exposure categories. The most common type of mutation found was single base substitutions (transitions and transversion). The prevalence of tumours with mutational transitions increased notably with tumour stage and grade and was higher in smokers than non-smokers. The trend increased with pack years of smoking. There were no trends found for prevalence of transitions and patient age or arsenic exposure category. A suggestion of a trend with transversion prevalence and the maximum 5-year peak concentration of arsenic in drinking water category and possibly tumour grade was found. Most of the mutations in tumours from smokers and non-smokers were G to A transitions at CpG sites. There was a similar prevalence of G to A transitions in arsenic-exposed ever smokers and never smokers in each exposure category. When ever-smoking and arsenic exposure were combined there was no increase in prevalence of *p53* mutations or IHC positivity than when each factor was examined alone.

This study found arsenic exposure via drinking water was not associated with an increase in *p53* mutation or P53 IHC positivity with the highest and lowest arsenic exposure categories showing little difference. There was also no evidence of an interaction between arsenic exposure and smoking. It is suggested that arsenic carcinogenesis is more likely to be caused through inhibition of DNA repair which increases the oxidative damage or genetic instability.

*Comment Some previous studies have also shown increased cancer risks from arsenic exposure in smokers vs non-smokers. This study suggests the mechanism of action by arsenic does not involve inactivation of the p53 gene.*

**Case-control study of bladder cancer and drinking water arsenic in the Western United States.**
Steinmaus C, Yuan Y, Bates MN, Smith AH. *Am J Epidemiol* 2003 **158**:1193-201

This case-control study was undertaken to investigate bladder cancer risk in a population exposed to low to moderate arsenic levels in drinking water in the western United States. There were six counties studied in western Nevada as well as Kings County in California. The cities of Hanford in California and Fallon in Nevada which account for 21 percent of the population in the study area, have historically been the two largest populations in the United States exposed to drinking water arsenic around 100 micrograms/L. In contrast the remainder of the study area has considerably lower arsenic levels.

In Nevada the Cancer Registry, hospitals and physicians provided lists of subjects diagnosed with bladder cancer between 1994 and 2000 who lived in the study area. In California the Cancer Registry of Central California provided lists of cases for the study period. Controls without a history of bladder cancer under the age of 65 were recruited by random digit dialing and were frequency matched to cases by 5-year age group and gender. Controls over 65 were randomly selected using Health Care Financing Administration rolls or random digit dialing.

All participants were interviewed using a standardised questionnaire. If participants were deceased the nearest relative was interviewed if possible. Participants provided the addresses or location of all residences they had lived at for 6 months or longer over their lifetime. The participant's source of drinking water for each residence and water filter use was obtained. Participants were also asked their usual intake of drinking water and beverages made with tap water 1 year prior to the interview or prior to any recent illness, 20 years ago and 40 years ago. The amount of tap water consumed at home, work and away from home and work was provided separately. Participants were also asked about jobs they held for 6 months or longer, and smoking history.

Arsenic exposure for each participant was calculated by matching each residence within the study area to a water arsenic measurement for that residence. Arsenic measurements for all community-supplied drinking water within the study area were provided by the Nevada State Health Division and the California Department of Health Services. Arsenic measurements for private wells were obtained from the Nevada State Health Department or the residence was visited and water sampled. For wells that couldn't be located, proxy measurements were used.

There were 181 cases and 328 controls included in the study. Odds ratios were calculated and were around 1.0 when exposure lags of 5 and 20 years were used. When the exposure lag was 40 years, odds ratios above 1.0 were found for arsenic intakes higher than 80 micrograms/day, however none of the confidence intervals excluded the null values (ie none were statistically significant). In smokers with intakes greater then 80 micrograms/day for exposures of 40 years or more, odds ratios of 3.67 were found.

There were no apparent overall associations found between bladder cancer risk and the exposures investigated in this study. The overall risks were less than those predicted from data of highly exposed populations in Taiwan. There was some evidence seen of elevated relative risks for bladder cancer in smokers exposed to arsenic levels in drinking water around 200 µg/day. This study also provides added evidence to a long latency period between arsenic exposure and bladder cancer diagnosis.

*Comment While prolonged exposure to high levels of arsenic in drinking water (several hundred micrograms per litre and higher) undoubtedly causes an increased risk of cancer and other adverse health effects, the degree of risk associated with lower levels of exposure is a subject of considerable scientific debate. Some risk modelling estimates have suggested that long term cancer risks from consuming water at 50 micrograms/L may be as high as 1 in 100, but the results of this study do not support such high risk levels.*

**Demand-based water options for arsenic mitigation: an experience from rural Bangladesh.**
Hoque BA, Hoque MM, Ahmed T, Islam S, Azad AK, Ali N, Hossain M, Hossain MS. *Public Health* 2004 **118**:70-7

In Bangladesh it is estimated that 35-77 million of the 125 million people are at risk of drinking arsenic-contaminated tubewell water. This article describes a relief action project of the Environment and Population Research Center in collaboration with Rotary International in which people in a part of arsenic-affected district of rural Srinagar, chose, installed and used their water options.

The project involved testing tubewell water samples for arsenic, creating community awareness about the health and social impacts of drinking arsenic-contaminated water, advising on safe water options and their installation and sharing of installation costs. The main intervention activities were undertaken from October 1999 to November 2000, and subsequently from November 2000 to April 2003, follow-up monitoring about the use of water options occurred. Baseline surveys were performed in November 1999 of 200 random households and final surveys were conducted in October 2000. Participants were asked questions on selected socio-economic parameters and characteristics of water used. Stored water was tested for arsenic content. All newly installed water options were sampled at installation and then at around three-monthly intervals and measured for pH, faecal coliform bacteria and arsenic concentration. A day-long observation of water use at every community based option was conducted between September and November 2000. There were also ten key informant interviews and three focus group discussions conducted.

An arsenic level higher than 0.05 mg/l was found in about 85% of the 912 tubewell water samples tested. There were 11 options promoted during the project which included groundwater, surface water and rainwater harvesting for individual households as well as community managed technologies. It was found that most people, in particular women desired piped water and hand-operated deep tubewells were also requested. There were 4 cluster-based motorised piped water systems installed, 20 home-based arsenic-removal options of two different types and an arsenic-removal filter plant. The public contributed over one-third of the installations cost of these systems and 100% of all operation and maintenance costs. Within a few weeks of installation the home-based options and filter plant were abandoned because they required too much care, discharged small amounts of water at low rates, were hard to maintain and produced water of poor aesthetic quality. At baseline 87% of families drank arsenic-contaminated water and in the final survey 54% of families drank contaminated water.

It was found that when the public are given the chance to have input into their water supply development and their well-being conditions, effective results are more likely to be achieved than if pre-determined options selected only for low cost are promoted. While people may be concerned about the health effects of arsenic, they will not accept alternative supplies which are of poor aesthetic quality, or which are inconvenient or difficult to manage. A small cluster-based supply of piped water from a centrally treated system is recommended for arsenic affected areas as this would allow for better control of water quality and water management than household based treatment.

Consumer aspects

**Do reports on drinking water quality affect customers' concerns?**
Johnson B B. Experiments in report content. *Risk Anal* 2003;**23** (5):985-98.

As part of the Safe Drinking Water Act Amendments of 1996, all United States utilities were required to mail annual reports to their customers on drinking water quality by October 1999. A study was conducted to examine customer reactions to diverse hypothetical versions of such reports. The hypothetical reports were either Qualitative (without water quality numbers, therefore not meeting USEPA rules), Basic, with minimal information meeting the rules or Extended, also including reading aids and utility performance information. Each of the report

versions came in two varieties, one with and one without a violation of a health standard. A seventh version was used as a control which included no report but just some general questions common to all versions.

There were 494 residential customers from a New Jersey utility randomly selected to participate. Customers were sent a report and questionnaires with general questions on drinking water quality followed by questions to measure customers' reactions and views on water quality management and risk management. Controls were sent only the general questions. There were 277 completed questionnaires received. ANOVA was the main analytical method, with post-hoc analyses.

Overall, reading water quality reports did not change customers' evaluations of water quality and utility performance from those of the control group, who saw no report. Violations did produce a higher mean "Concern" scale response compared to No-Violation conditions but these results were not consistent and often not significant when adjusted. The lack of details in the Qualitative reports was of concern to utility customers whereas reports that included detailed tables on drinking water quality were more satisfactory. This confirmed the EPA decision to have the actual contaminant levels reported by utilities. However extended reports did only slightly better than Basic versions on this measure.

Many of the respondents had difficulty identifying whether substance amounts were present or absent or violations occurred even though there was a summary on the front page of each report. However even those that accurately identified these factors did not show much variation from the group as a whole in their pattern of responses. It was found that generic risk beliefs such as a feeling there were serious local environmental problems where they lived, or that they had little of control over risks to their health, were more important in influencing attitudes towards water quality and utility performance than risk communication attributes.

The findings of the study suggest that the content of annual water quality reports may not make much difference to customers' concerns about drinking water quality.

Cyanobacteria

**Contamination of drinking water in the Czech Republic by microcystins.**
Blaha L, Marsalek B. Archiv *Fur Hydrobiologie* 2003 **158**:421-29

This report presents data on the concentrations of dissolved microcystins in drinking water reservoirs, raw water and treated drinking waters in the Czech Republic. Possible risks were estimated by comparing microcystin amounts to the World Health Organisation provisional guideline value for microcystin-LR of 1 microgram /L. To assess the efficiency of microcystin removal during drinking water treatment processes, parallel sampling of the biomass, raw water and treated water in different plants was conducted.

Samples of the biomass (water blooms or benthic cyanobacterial mats) were collected at drinking water plants near to the points of raw water intake. A single sample of raw and a single sample of treated water were collected from the pipelines in the facilities of each plant. In one selected plant, duplicate pooled samples were collected after each treatment step. In localities where large concentrations of dissolved microcystins were found, repeated sampling was performed over the summer season.

There were 8 drinking water treatment plants in the Czech Republic studied with 13 biomass samples and 34 water samples analysed. The concentration of total microcystins in biomass of water blooms or benthic mats ranged from 8.4-1288 micrograms/g dry weight. Of the 13 raw water samples, 8 were positive for microcystins with a concentration ranging from 0.7-58 microgram/L. Detectable concentrations of microcystins were found in 5 samples of treated drinking water. When the amount of a single microcystins variant (microcystin-LR) and the sum of all microcystins was analysed, the WHO provisional guideline value of 1 microgram /L was exceeded in one and two samples respectively. Reasonably high

concentrations of both cell-bound and dissolved microcystins were found in samples taken from a treatment plant that collects water from a river. There was a high correlation between the amounts of total microcystins in the biomass of cyanobacteria and the calculated concentrations in the source surface reservoirs.

The amount of microcystin removal depended on the treatment technology. Flocculation/ filtration removed microcystins to less than detectable levels in the samples with the concentrations in the range of 2-3 micrograms /L. When ozonation or active carbon filtration was used, elimination of microcystins at higher concentrations was achieved. These two methods of water treatment are quite rare in the Czech Republic.

This study found a significant occurrence of microcystins in surface drinking water reservoirs and in raw and treated drinking water in the Czech Republic. This confirms that there is a risk of drinking water contaminated by cyanobacterial toxins from Czech treatment plants. Systematic monitoring of microcystins in drinking water in the Czech Republic is required.

Disinfection byproducts

**Disinfection by-products and other emerging contaminants in drinking water.**
Richardson SD. *Trac-Trends in Anal Chem* 2003 **22**:666-84

This article discusses drinking water contaminants that are emerging as possible public health concerns and the analytical methods that are being used presently for their determination.

Compounds of recent concern include brominated and iodinated compounds which form due to the reaction of the disinfectant (for example chlorine) with natural bromide or iodide present in the source waters. These brominated DBPs may be more carcinogenic than their chlorinated analogs and studies are also indicating that the iodinated compounds may be more toxic than their brominated analogs. Nitrosodimethylamine (NDMA), a possible human carcinogen, has recently been discovered and may be formed as a DBP from chloramine or chlorine disinfection. It has been shown that NDMA is generally present at 10 ng/L or less in chlorinated drinking water but can be found at levels of 100 ng/L or greater in wastewater treated with chlorine. The analytical techniques that have been used to measure DBPs in human exposure studies include: liquid-liquid extraction (LLE) with gas chromatography-electron capture detection (GC-ECD), purge-and-trap-GC/Mass spectrometry (MS) and glow discharge-ion-trap-MS.

Other contaminants that have emerged as important include pharmaceuticals and hormones which may be present in environmental waters because of incomplete removal in wastewater treatment or point-source discharges. There is concern about possible oestrogenic and other effects of these contaminants on humans and wildlife. It has not been determined whether levels found in drinking water pose a risk to human health. Many pharmaceuticals are highly polar and therefore to analyse them it is necessary to use either liquid chromatography (LC)/MS or an efficient derivatisation procedure along with GC/MS. There is difficulty in measuring oestrogens and progesterones in wastewater at mg/L levels.

Organotins are widely used in antifouling paints for ships and have been identified mostly in coastal waters and sediment. Of recent concern for drinking water is the finding that the organotin dibutyltin can leach from polyvinyl chloride pipe (PVC) at levels of 1 µg/L. Dibutyltin is used as heat stabilisers in PVC pipe and is highly neurotoxic. A variety of methods to analyse organotins have been developed including: GC with MS, atomic absorption spectrometry (AAS), flame photometry, inductively coupled plasma (ICP) or microwave-induced plasma atomic emission spectrometry (AES) as well as LC coupled to MS, ASS, ICP-MS and fluorescence detection.

Methyl-*tert*-butyl (MTBE) has become of concern as a drinking water contaminant because leaking underground gasoline-storage tanks and discharges of fuel from boats and other watercraft introduce it into groundwater and surface waters. Taste and odour problems in drinking water have been attributed to

MTBE and there are concerns about possible adverse health effects. Methods that have been used to measure amounts of MTBE include: headspace, purge-and-trap, or solid-phase microextraction (SPME) coupled with GC or GC/MS detection.

Perchlorate has recently become a significant environmental issue in the USA since it was discovered in a number of water supplies in western states. Ammonium perchlorate has been used as an oxygenate in solid propellants used for rockers, missiles and fireworks and contamination can also possibly occur through the use of fertilisers. Perchlorate may disrupt the thyroid gland's use of iodine in metabolic hormones and therefore affect normal metabolism, growth and development. Ion chromatography (IC) was found to be a good method for measuring perchlorate as it has low detection limits, is easy to use and because of its selectivity and availability. Other methods that also have low detection limits include electrospray ionization (ESI)-MS/MS, an ion-pair extraction-ESI-MS method and ESI-high-filed asymmetric waveform ion mobility spectrometry (FAIMS)-MS.

Also of recent concern has been the increase of harmful algal blooms which had led to an increase in the incidence of shellfish poisoning, large fish kills and deaths of livestock and wildlife as well as illness and death in humans exposed. The toxins produced by the algae are very potent neurotoxins or hepatotoxins. Recently cyanobacterial toxins have been found in finished drinking water which presents a human health risk. Methods that have been developed to measure algal toxins include: enzyme-linked immunosorbent assays (ELISA), protein phosphatase inhibition assays, LC, LC/ELISA, LC/MS, LC/MS/MS, matrix-assisted laser desorption ionization (MALDI)-MS, ESI-FAIMS-MS, and SPME-LC-fluorescence.

Fluoride

**Concentration levels of fluoride in bottled drinking water.**
Johnson S A, DeBiase C. *J Den Hyg* 2003;**77** (3):161-7.

This studied aimed to classify brands of bottled water by manufacturer assigned labelling to verify the concentration of fluoride for those brands that state they contain fluoride, and to determine if fluoride is present in those brands that do not list fluoride concentration or list it as undetermined on the label. Bottled water consumption has increased dramatically in the U.S. with a six-fold increase between 1981 and 1997. There is concern that bottled water may contain less than optimal levels or no fluoride where as tap water in the U.S. usually contains optimum levels. The labelling of bottled water is governed by the U.S. Food and Drug Administration (FDA) and the International Bottled Water Association. FDA regulations do not require companies to list fluoride concentration unless it has been added to water and if it has, only its presence need be listed.

A sample of 65 brands of bottled drinking waters in West Virginia was collected from convenience stores, supermarkets, drugstores, mall restaurants, fast food restaurants and discount department stores throughout the state. There were six types of bottled water found based on common wording on the package: artesian, drinking, purified, sparkling, spring and sport. Samples of 150 mL from each brand of water were tested for fluoride concentration.

It was found that 95% of the bottled water tested did not list fluoride on the label. Of the bottled water tested, eight (12.3%) contained optimal fluoride concentration ranging from 0.63 mg/L to 1.20 mg/L. Of these eight only four listed fluoride as an ingredient and only three listed that exact fluoride concentration on the label. Of the brands without fluoride information on the label or fluoride information provided from the manufacturer, the fluoride concentration ranged from 0 to 1.2 mg/L. Only 15.5% of this group actually did not contain fluoride. Of those brands that stated a fluoride content none of them identified a concentration equivalent to the results from the chemical analysis in this study with three of the brands having a higher concentration than listed and four having a lower concentration than listed. It was found that 11% of the bottled waters were obtained from municipal water sources.

From this study it can be concluded that: drinking only bottled water may lead to inadequate fluoride intake to maintain optimal dental health, the majority of bottled waters contain low concentrations of fluoride and therefore are not contributing to the risk of fluorosis, bottled water labelling in relation to fluoride content is unsatisfactory and inaccurate, and most bottled waters are almost the same even though their naming and packaging are different

Hardness

**Association of death from renal failure with calcium levels in drinking water.**
Hwang S J, Lai Y H, Chiu H F, Liao M C, Yang C Y. *J Toxicol Environ Health-Part A* 2003;**66** (24):2327-35.

A matched case-control study was conducted to examine the association between the risk of death from renal failure (RF) and the levels of calcium in drinking water from municipal supplies. In Taiwan the incidence of end-stage renal disease has increased from 120 per 100,000 in 1990 to 311 per 100,000 per 100,000 in 2000. There were 322 of the 361 municipalities in Taiwan included in the study. Information on all deaths of Taiwan residents from 1991 through 2000 was obtained from the Bureau of Vital Statistics of the Taiwan Provincial Department of Health. Cases included all deaths due to RF which occurred in people between 50 and 69 years of age. Controls were those who died from diseases other than a specified group of diseases (including several types of cancer, cardiovascular disease, hypertension, diabetes mellitus and cerebrovascular disease) which have previously been reported with negative correlations between mortality and hardness (calcium and magnesium) levels in drinking water. Controls were selected randomly from a set of possible controls and pair-matched to RF cases by year of birth and year of death. All subjects had to have lived and died in the same municipality to be included in the analysis.

Levels of calcium and magnesium in the treated drinking water of each municipality were obtained from the Taiwan Water Supply Corporation (1997). Each waterworks plant had four samples of treated water collected, one each season. There were 70 municipalities excluded as they were supplied from more than one waterwork source. It was assumed that the municipality of residence for all subjects was their source of calcium and magnesium exposure via drinking water.

There were complete records for 2469 RF-related deaths for the study period. The odds ratios (ORs) for death associated with RF were significantly higher for the group with the highest levels of calcium in their drinking water. Adjustment for possible confounders of age, sex, urbanisation and magnesium levels in drinking water only slightly altered the ORs. Adjusted ORs (95% CI) were 1.21 (1.03-1.43) for those with water calcium levels between 25.1 and 43.0 mg/L and 1.34 (1.12-1.60) for those with calcium levels of 43.3 mg/L or greater, compared to the reference level of less than 24.4 mg/L. A significant trend was found toward an elevated risk of death from RF with increasing calcium levels in drinking water.

This study shows a possible association between calcium intake in drinking water and mortality for RF patients which is an important finding for the water industry and for human health risk assessment. Studies are needed to gather more exact estimates of intake of calcium from food and water by individuals to find out how much each source of calcium contributes towards disease.

*Comment ESRD is a complete or near complete failure of kidney function characterised by inability to excrete wastes, concentrate urine, and regulate electrolytes. People with this condition have altered calcium metabolism and often exhibit accumulation of calcium in the body leading to a range of effects which may contribute to premature mortality.*
*This study was ecological in nature and did not assess individual consumption of drinking water or dietary calcium intake in cases or controls. Calcium exposure was inferred from the place of residence, and the duration of residence does not appear to have been considered in the analysis. As noted by the authors, there is a body of evidence suggesting hard water has beneficial effects on a range of other diseases which are more common causes of illness and death than ESRD.*

Nitrate

**Nitrate in public water supplies and the risk of colon and rectum cancers.**
De Roos AJ, Ward MH, Lynch CF, Cantor KP. *Epidemiology*. 2003 **14**:640-9

Normally most human intake of nitrate is from the consumption of vegetables, however greater than 50% of nitrate intake can come from drinking water when levels are above the US maximum contaminant level of 10 mg/L. In humans nitrate is reduce to nitrite mainly by oral bacteria. In the stomach and the gut nitrite can then react by nitrosation with amines and amides to form N-nitroso compounds many of which are carcinogenic to animals. The human data on the carcinogenicity of N-nitroso compounds is limited however. The formation of N-nitroso compounds is inhibited by particular nutrients such as Vitamin C and by increased meat intake.

A case-control study was conducted in Iowa from 1986 to 1989 to investigate the association between nitrate in public water supplies and the incidence of colon and rectum cancers. In Iowa, elevated levels of nitrate have been found in groundwater and surface drinking water sources. Cases were obtained from the Iowa Cancer Registry as well as through a rapid reporting system during 1987. To be eligible cases needed to be Iowa residents, aged 40 to 85 years and have recently diagnosed colon cancer in 1987 or rectum cancer in 1986 or 1987. Controls were recruited from 1986 through 1990 from driver's licence records if aged under 65 and Health Care Financing Administration listings if aged 65 or over. A questionnaire was mailed to all participants and information was obtained on: demographic factors, smoking history, diet, occupational history, and other lifestyle and medical factors.

A lifetime residential history and the primary source of drinking water were also obtained for each residence since birth. Amount of tap water consumed for usual water source at home and water sources outside home was collected. Data was obtained from the Center for Health Effects of Environmental Contaminants on nitrate levels for Iowa towns for the years 1934 through to 1988. Nitrate levels in Iowa towns were linked to participants' water source histories. Nutrient intake was assessed using a food frequency questionnaire. The period from 1960 onwards was analysed as this was when nitrate measurements were more frequent, and analysis was limited to those people with public water supplies for which data was available for over 70% of the time.

There were 376 colon cancer cases and 338 rectum cancer cases included in the study and 1244 controls. There was little association between average drinking water nitrate level since 1960 and colon and rectum cancers. Slight decreased risks were associated with the middle-range levels of average nitrate-nitrogen (from 3 to 5 mg/L). For average nitrate-nitrogen level greater than 10 mg/L for 1 year or longer no association with either cancer was found. For more than 10 years with average nitrate concentration above 5 mg/L the odds ratio (OR) for colon cancer was 1.2 (CI=0.9-1.6) and for rectum cancer OR was 1.1 (CI=0.7-1.5). An increased risk of colon cancer was found for nitrate exposure above 10 years with average nitrate above 5 mg/L among subgroups with low vitamin C intake (OR=2.0; CI=1.2-3.3) and high meat intake (OR=2.2; CI=1.4-3.6). No similar patterns were found for rectum cancer.

Overall, little association was found for either cancer and average nitrate-nitrogen levels greater than 5 or 10 mg/L. Low vitamin C intake and high meat intake and drinking water nitrate exposure were possibly associated with increased colon cancer risk. The authors comment that increased cancer risks from nitrate in drinking water, if they exist at all, may occur only in susceptible subpopulations.

*Comment* *An accompanying commentary Epidemiology and Drinking Water: Are we running dry? by K Steenland and C Moe (p635-636) discusses the limitations of retrospective studies on drinking water including the difficulty in assessing long term water consumption, limitations of historical water quality data for public supplies, and often complete absence of data for private supplies. They suggest that even well conducted retrospective studies will have considerable errors in exposure assessment and their results will always be subject to doubts about the role of possible confounders.*

Uranium

**Uranium gastrointestinal absorption: the f1 factor in humans.**
Limson Zamora M, Zielinski J M, Meyerhof D, Moodie G, Falcomer R, Tracy B. *Radiat Protect Dosimetry* 2003;**105** (1-4):55-60.

When contaminants are ingested the long-term health risk to the exposed person is dependant on the fraction ($f_1$ ) absorbed into the extracellular fluid and later transported to and retained in target tissues, not the entire amount ingested. There is large variation in the $f_1$ values published for uranium, therefore a study was undertaken by the Department of Health, Canada to establish the $f_1$ value that would be most appropriate to use for developing and setting of the uranium guideline for drinking water.

Males and females between 20 and 70 years of age without medical problems were recruited from two communities. One of the communities was rural with drinking water supplied from drilled wells with elevated levels of uranium in the water. The other community was urban with a municipal drinking water system and water containing very low levels of uranium. The duplicate diet method was used to assess uranium intake from food. Participants collected beverages and food over 3 consecutive days equal in volume and weight, and prepared in the same manner as that consumed. Urine and faecal samples were also collected concurrently over a 3 day period. Levels of uranium in food, beverages, urine and faecal samples were measured by inductively coupled plasma mass spectrometry (ICP-MAS). The $f_1$ values were then calculated for all participants.

There were 30 participants from the rural area with uranium drinking water levels ranging from 2 to 780 micrograms/L. In the urban area there were 20 participants with a uranium level in the tap water of 0.2 micrograms/L. Values for $f_1$ for the 50 participants ranged from 0.001 to 0.063 and the daily uranium intake corresponding to these values ranged from 0.37 to 573 micrograms/day. The median value was 0.009. The effects of gender and age, duration of exposure, total uranium intake and allocation of intake between food and water were all examined in relation to the study data. The $f_1$ values were not dependant on age, gender or duration of exposure (duration of exposure ranged from 17 months to 59 years). The $f_1$ value was not found to be dependant on intake rates at the levels seen in this study. Comparison of the two population samples indicated that uranium was absorbed equally well from food and water.

The International Commission on Radiological Protection (ICRP) Publication 69 recommends using 0.02 as the appropriate $f_1$ value for adults and children older than 1 year. In this study 78% of the study population had values below 0.02 therefore these data substantiate the use of this value as a conservative estimate for gastrointestinal absorption of uranium.

Viruses

**Waterborne outbreak of gastroenteritis associated with a norovirus.**
Parshionikar S U, Willian-True S, Fout G S*, et al. Appl Environ Microbiol* 2003;**69** (9):5263-5268.

An outbreak of acute gastroenteritis occurred among those who dined at a tourist saloon in central Wyoming during September and October 2001. The outbreak was investigated by the Wyoming Department of Health and an epidemiological and environmental investigation was conducted and molecular data analysis was performed. On the basis of incubation period, duration of illness and symptoms observed, the etiological agent of the outbreak was suspected to be human caliciviruses (HuCVs).

A retrospective cohort study was conducted by telephone interview following the report of an outbreak of gastroenteritis. An environmental survey of the saloon was conducted to investigate the construction of the well and the possible sources of well water contamination. Samples from the well water and from tap water were collected on the 24 October and were tested for faecal and total coliforms. Water samples were also processed for viruses. Stool samples were collected from three ill patrons. Both the processed water samples and stool

samples were analysed by reverse transcription-PCR (RT-PCR) for the presence of HuCVs. All positive RT-PCR results were then confirmed by sequence and phylogenetic analyses of cloned RT-PCR products.

Of the 111 patrons interviewed by telephone, 84 (76%) developed acute gastroenteritis. The illness on average lasted 2 days. Those patrons that were ill were 4.5 times more likely to have been exposed to drinking water and/or ice than unaffected patrons. None of the 41 food items on the menu were statistically associated with illness.

The environmental survey of the premises showed that the saloon's well was 50ft away from its septic tank which is the minimum construction distance specified. However the septic tank showed signs of being damaged and the leach field from another septic tank was within 50 ft of the well when specifications require 100ft. The well was also found to be 100 ft away from the effluent disposal of a recreation vehicle park located up hill of the saloon. Routine water quality monitoring records showed that the well had been positive for faecal coliforms in January 1995 and September 2001. A chlorinator had been installed after the positive coliform test in 1995 however after examination following the outbreak it was found to have failed. Of the six well samples taken, five tested positive for faecal coliforms and all tested positive for total coliforms.

HuCV analysis revealed a norovirus genogroup 1, subtype 3, strain was present in the well water sample and two stool samples. In one stool sample a genogroup II, subtype 6 stain was detected. The finding of the same strain of norovirus in the well water and stool samples suggests an association between exposure to well water and the outbreak of gastroenteritis. The presence of the different genotype in one stool samples may indicate multiple norovirus strains were involved in the outbreak.

Noroviruses have been infrequently detected in waterborne disease outbreaks and this is partly because of a lack of appropriately sensitive methods. The molecular method used in this investigation was more sensitive than methods used during other outbreaks. This study showed how molecular methods can be used in addition to environmental and epidemiological data to investigate outbreaks.

Water Quality

**Prevalence of Escherichia coli O157:H7 and Salmonella spp. in surface waters of southern Alberta and its relation to manure sources.**
Johnson J Y, Thomas J E, Graham T A*, et al. Can J Microbiol* 2003;**49** (5):326-35.

A 2-year study was conducted to estimate the prevalence of *Escherichia coli* 0157:H7 and *Salmonella* spp. in the surface water within the basin of the Oldman River in southern Alberta, Canada. This drainage basin is the main water source for agriculture, industry and drinking and recreational waters used by rural and urban centres. Around 10% of this area is irrigated agricultural land with irrigated water used to maintain an intensive livestock industry which has increased significantly since 1991. Waterborne disease outbreaks have occurred in public drinking water supplies in this region which were inadequately treated after contamination with surface water. Recreational water outbreaks from enteric pathogens have also been recorded.

Water sampling sites were chosen to be representative of the region. A total of 522 samples were collected from 69 sites in 1999. During the following year 84 sites were sampled with 961 samples collected. Water samples were analysed for *E. coli* 0157:H7 (by immunomagnetic separation) and *Salmonella* spp (by selective enrichment). The prevalence of both pathogens in the water samples was calculated. Data was provided of mapped manure output from confined animal agricultural operations in southern Alberta. Animal manure units (AMU) were estimated from bovine, swine and poultry feeding operations.

In 1999, *Salmonella* spp. were isolated from 14 of the 468 samples with a prevalence of 3.0%. In 2000, *Salmonella* spp. were isolated from 74 of the 961 samples with a prevalence of 7.7%, representing a 2.6-fold increase in the prevalence of *Salmonella* spp. On average for 1999 and 2000, *Salmonella* spp. were

detected in 6.2% of the water samples. A large proportion of the 38 samples from municipal storm drain sites contained *Salmonella* spp. In 1999 and 2000, *E. coli* 0157:H7 was isolated from 13 of 1483 water samples with a prevalence of 0.9%. Most sites with *E. coli* 0157:H7 contamination were located close to some type of agricultural activity and these areas were found to have low to moderate livestock density or were downstream of high-density livestock operations. Water collected from regions with high AMU were mostly not contaminated with *E. coli* 0157:H7, however the prevalence of *Salmonella* spp. was high in some instances. No direct correlation between bacterial prevalence and manure production from confined livestock feeding operations was found.

This study was able to isolate *E. coli* 0157:H7 in surface waters collected from a Canadian watershed which makes it the first study of this type to do so.

Both *E. coli* 0157:H7 and *Salmonella* spp. were present in the water samples, and could pose a risk to human health if untreated water is consumed. The effect of local AMU on water contamination was modelled in this study, however geography and weather variables were not considered and these variables may influence bacterial runoff. Other factors such as environmental conditions at the time of sampling and variations in time, amount and frequency of manure application onto agricultural lands may have contributed to the amount of surface water contamination with these bacterial pathogens.

*Disclaimer*

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Martha Sinclair
Epidemiology and Preventive Medicine
Monash University - Central & Eastern Clinical School
Alfred Hospital, Melbourne VIC 3004
AUSTRALIA

Phone +61 (0)3 9903 0571
Fax +61 (0)3 9903 0576
Email martha.sinclair @med.monash.edu.au

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