Health Stream

INFORMATION AND ANALYSIS FOR WATER AND HEALTH PROFESSIONALS

Issue 28 *Public Health Newsletter of the CRC for Water Quality and Treatment* December 2002

In this Issue:

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.

Australian Drinking Water Guidelines Rolling Revision

On 2 November 2002, the National Health and Medical Research Council (NHMRC) and the Natural Resource Management Ministerial Council (NRMMC) released the current revisions to the Australian Drinking Water Guidelines incorporating the *Framework for Management of Drinking Water Quality* for three months public consultation.

The Australian Drinking Water Guidelines (the Guidelines) recognise the primary importance of a preventive multibarrier approach for minimising health risk in water supply systems, however it has been observed that in practice there has been a heavy reliance on the numerical guideline values and monitoring these for compliance without sufficient recognition of the importance of overall system management for assuring safe water. The *Framework for Management of Drinking Water Quality* (the Framework) was developed to emphasise a more preventive approach in which greater attention and better measures of control are provided for system management, and to foster a more holistic approach to, and understanding of, drinking water quality management.

In the Australian water industry, risk management and quality management are increasingly been used as a means of assuring drinking water quality by increasing focus on more preventive approaches. The Framework is a quality management approach designed specifically for drinking water supply systems. It provides a preventive risk management strategy from catchment to consumer, and includes principles of established systems such as ISO 9001 (Quality Management), AS/NZS 4360 (Risk

Management) and the Hazard Analysis and Critical Control Point (HACCP) system which is used in the food industry but applies them in a drinking supply context to support consistent and comprehensive implementation.

The Framework provides holistic guidance on a wide range of issues that should be considered for management of drinking water quality. Its foundation is to promote an understanding of the entire water supply system, the hazards and events that can compromise drinking water quality and safety, and the development of effective preventive measures to control the hazards, including the application of multiple barriers and the establishment of Critical Control Points to reduce exposures to hazards.

Additionally, the optimisation and continuous control of operations are seen as crucial components as even short periods of suboptimal system performance can represent serious risk to public health. Effective control is achieved through the establishment of operating procedures, a monitoring protocol for operational performance, including the selection of appropriate parameters and criteria, and the corrective actions to control excursions from established criteria.

The Framework addresses not only the technical issues of water supply but also aspects such as corporate commitment, communication, training and relationships with other stakeholders and with consumers. The principles of management outlined in the Framework are intended to be applicable for all water supply systems regardless of size and system complexity. It allows sufficient flexibility for individual systems to implement it in a manner that suits their own circumstances, needs and preferences.

The *Framework for Management of Drinking Water Quality* was released for public consultation in mid-2001 and since this time the entire Australian Drinking Water Guidelines document has been restructured and reorganised to improve clarity and incorporate the Framework's twelve elements and guidance as its central focus.

The Guidelines are now organised into five parts:

Introduction

Chapter 1 – Guiding Principles

Part I – Management of Drinking Water Quality

Chapter 2 – Framework for Management of Drinking Water Quality: Overview

Chapter 3 – Framework for Management of Drinking Water Quality: The Twelve Elements

Chapter 4 – Framework for Management of Drinking Water Quality: Application to Small Water Supplies

Part II – Description of Water Quality

Chapter 5 - Microbial Quality of Drinking Water

Chapter 6 - Physical and Chemical Quality of Drinking Water

Chapter 7 - Radiological Quality of Drinking Water

Chapter 8 - Drinking Water Treatment Chemicals (under development)

Part III - Monitoring

Chapter 9 - Overview of Monitoring

Chapter 10 - Monitoring for Specific Characteristics

Part IV - Procedural Sheets

Part V - Fact Sheets

Appendix – Additional Guidance on Elements 2 and 3 of the Framework for Management of Drinking Water Quality

Making a Submission

You are invited to make a submission to the NHMRC about the draft Guidelines. A copy of the revised Guidelines incorporating the *Framework for Management of Drinking Water Quality* can be downloaded from the NHMRC website:

www.health.gov.au/nhmrc/advice/drink.htm

or obtained by contacting Phil Callan:

Fax +61 (0)2 6289 9898

or by emailing:

lorraine.o'connor@nhmrc.gov.au

To assist in the preparation of submissions, the NHMRC has produced a pamphlet, Public Consultation - Procedures for Making Submissions, available at:

www.nhmrc.gov.au/publications/pdf/nh16.pdf

The closing date for submissions is:

Friday 24 January 2003

US Waterborne Disease Outbreaks 1999-2000

The US Centers for Disease Control and Prevention have released a report on waterborne disease outbreaks occurring in the US and its territories during 1999 and 2000. The report summarises information on outbreaks from drinking water and recreational water sources reported by state, territorial and local public health departments. An outbreak is generally defined as an illness affecting two or more people after exposure to a common water source, with water being implicated as the source of disease on the basis of epidemiological evidence. For instances of chemical poisoning supported by water quality data, and primary amoebic meningoencephalitis, a single case is considered to represent an outbreak. Outbreaks associated with contamination of water at the point of use rather than at the water source or distribution system were excluded.

Drinking water outbreaks - a total of 39 outbreaks were reported from 25 states, with the cause being identified for 20 outbreaks (51%). The majority of identified causes were microbial pathogens with only two very small outbreaks attributed to chemical contamination. It was estimated that a total of 2,068 people were affected by the outbreaks, 122 were hospitalised and two died as a result of the outbreaks. Outbreaks were more common in the summer months.

The largest outbreak (affecting 781 people) occurred at a fairground in New York state when unchlorinated groundwater was used to make beverages and ice[(1)]. This mixed outbreak of *Campylobacter jejuni* and *E.coli* O157:H7 was responsible for the two reported deaths. The most geographically dispersed outbreak was associated with consuming water from private wells in a limestone area of the southeastern US and with two brands of bottled water. 84 people from 10 states were infected with *Salmonella* Bareilly. Investigations showed both brands of bottled water were processed at the same plant using shared equipment. The bottling process included filtration, UV and ozone treatment but bacterial contamination of some bottled water samples suggested that treatment processes had been interrupted or were sub-optimal. The exact source of the contamination was not identified.

The causative agents, type of water source, the number of outbreaks and cases for drinking water outbreaks are summarised in the table below. In three of the surface water outbreaks, water was consumed from sources which were not intended for drinking (irrigation water supplies).

	Surface water	**Ground water**
	Outbreaks (Cases)	
Protozoa		
Giardia	2 (31)	4 (21)
Cryptosporidium	0	1(5)
Bacteria		
Campylobacter jejuni	0	1 (15)
E.coli O157:H7	3 (38)	1 (22)
Salmonella typhimurium	0	1 (124)
Salmonella Bareilly	0	1 (84)
Campylobacter jejuni + *E.coli* O157:H7 or O111	1 (102)	1 (781)
Viruses		
Norwalk-like	0	3 (356)
SRV (small round-structured virus)	0	1 (70)
Chemical		
Nitrate	0	1 (1)
Sodium Hydroxide	0	1 (2)
Unknown cause	4 (119)	13 (297)
TOTAL	**10 (295)**	**29 (1778)**

Assessment of the underlying deficiencies in water systems revealed that 17 outbreaks (43.6%) could be attributed to untreated groundwater, nine (23.1%) to inadequate or interrupted water treatment, six (15.4%) to distribution system problems, one (2.6%) to untreated surface water, with the remaining 6 (5.4%) attributed to miscellaneous problems, or with no specific problem able to be identified in the water supply system.

Recreational water outbreaks - during the 2-year period 59 outbreaks were reported by 23 states. Microbial causative agents were identified in 44 outbreaks (74.6%). Recreational water outbreaks were estimated to have caused 2,093 cases of illness, 25 hospitalisations and four deaths. The majority of outbreaks (36 or 61.0%) involved gastroenteritis symptoms, with dermatitis outbreaks being the next most common category (15, 25.4%). There were four outbreaks of meningoencephalitis (each involving a single fatal case), and one outbreak each of leptospirosis (21 cases), Pontiac fever (20 cases), acute respiratory infection of unknown cause (12 cases), and chemical keratitis (3 cases). All of the leptospirosis cases occurred among US competitors in an adventure race held in Guam (a US territory).

Among gastroenteritis outbreaks the most commonly identified cause was *Cryptosporidium parvum* (16 outbreaks), followed by *E. coli* O157:H7 (4 outbreaks), *Shigella* species (3), Norwalk-like virus (3), *Giardia lamblia* (1*), E. coli* O121:H19 (1), *Campylobacter jejuni* (1), and one mixed outbreak of *Shigella sonnei* and *Cryptosporidium parvum*. For six gastroenteritis outbreaks no cause was identified. The total number of cases for all gastroenteritis outbreaks was 1860, with individual outbreaks ranging from 2 to 700 people affected.

Gastroenteritis outbreaks were most common in the summer months. The majority of outbreaks were associated with swimming and wading pools (21 of 36 outbreaks or 58.3%). Lakes and ponds were responsible for 11 outbreaks (30.5%), and single outbreaks were associated with an interactive fountain, a hot spring, an outdoor spring, and playing in ditch water.

The majority of dermatitis outbreaks were associated with *Pseudomonas aeruginosa* in pools or hot tubs (12 of 15 outbreaks or 80%). The remaining three dermatitis outbreaks were attributed to Schistosomes in freshwater lakes.

Occupational water outbreaks - Two outbreaks were identified in this category. The first involved two cases of leptospirosis that occurred in workers who were landscaping a pond in Hawaii. Both had been exposed to pond water over several days and had multiple skin abrasions that would have facilitated infection. One person required hospitalisation. The second outbreak involved 15 cases of acute respiratory illness including 13 hospitalisations among workers at a sugar beet processing factory. All affected workers had been exposed to water spray when using high pressure cleaning equipment. Serological tests showed 4 workers were positive for *Legionella pneumophila* antibodies, and *Legionella* genetic material was also detected in sputum samples from three workers. Source water used in cleaning was found to have high counts of *L. pneumophila* (10^5 CFU /ml) and high levels of bacterial endotoxin. The outbreak was classified as Pontiac fever.

Quality of data - for each outbreak the available water quality data and epidemiological data were assessed to determine the strength of evidence on a four-level scale. Only nine of the drinking water related outbreaks were considered to have both water quality and epidemiological data of an adequate nature. Similarly only seven of the recreational water outbreaks had adequate data of both types. However the authors note that not all outbreaks can or should be investigated in detail, and state health authorities must balance demands on personnel and resources with the perceived public health importance of the particular outbreak.

Trends in occurrence - The number of drinking water related outbreaks reported in this 2-year interval (39) is higher than the previous interval (17). The number of recreational water outbreaks (59) also increased compared to the previous interval (32). However it is not possible to determine whether these increases reflect changes in the incidence of outbreaks, or improvements in detection, changes in physician awareness, investigative procedures and resources, or laboratory testing practices. Despite the increase in the number of reported drinking water outbreaks, the total number of people affected was similar to previous reporting period. This reflects increasing reports of outbreaks in small non-community and private systems, many of which are private wells not covered by EPA regulations.

1) Reported in Health Stream Issue 15 - September 1999.

Naegleria Deaths In Arizona

Residents of the Arizona towns of Peoria and Glendale have been shocked by the deaths of two five-year old boys from amoebic meningitis caused by *Naegleria fowleri*. The source of the infections has not been positively established but suspicion has fallen on a small unchlorinated ground water supply operated by a private company. This supply was taken off-line on 3 November, a boil water notice was issued and 6,000 consumers were warned not to use unboiled tap water for drinking, cooking or bathing. Schools and restaurants in the suspect area were also closed, and residents were advised to drain and clean spas and hyperchlorinate swimming pools. Supply to the affected area was switched to a chlorinated surface water source, and a flushing program with hyperchlorinated water was carried out to remove possible contamination from the water distribution system.

One of the victims lived in Peoria and the other in the neighbouring town of Glendale, some four miles away. They attended separate schools, however the Glendale boy frequently visited his grandparents' home a few blocks from the other boy's residence in Peoria. Both boys became ill on 9 October and died a few days later on 12 and 13 October respectively. Health authorities then began investigating possible common sources of *Naegleria* exposure including drinking water, pools, bathtubs, spas and fountains.

About 100,000 of Peoria's 120,000 residents receive chlorinated drinking water from the municipal supply. This supply is predominantly drawn from surface water sources but is supplemented by groundwater in times of high demand. As Arizona state law prevents counties from supplying water to areas outside the incorporated municipal zones, the remaining 20,000 residents in the rapidly growing town are served by private water companies which mainly rely on groundwater sources. Some of these companies chlorinate their groundwater supplies and some do not. The suspect water supply is drawn from a deep aquifer and is not routinely chlorinated, although periodic chlorination has been used after new connections, line breaks or incidents that might allow ingress of microbial contamination.

Tests by the Centers for Disease Control and Prevention have detected *N. fowleri* in three samples:

- one pre-chlorination water sample from a municipal well that was routinely chlorinated
- one tank water sample from the suspect unchlorinated groundwater system
- the refrigerator filter from the home of the grandparents of one of the boys

The chlorinated well is believed unlikely to be the source of infection as chlorination is effective in killing *N. fowleri.*

Naegleria fowleri is a free living amoeba which is common in the environment and grows optimally at temperatures of 35 to 45 degrees C. Exposure to the organism is believed to be relatively common but infections resulting in illness are rare. The disease was first described in 1965 by Dr Malcolm Fowler, an Australian pathologist, who identified the amoeba in a patient who had died from meningitis.

Most reported cases of *N. fowleri* meningitis are associated with swimming in natural surface freshwater bodies, and infection occurs through introduction of the organism into the nasal cavities. Cases are often reported to be associated with jumping or falling into the water, providing conditions where water is forced into the nose at pressure. The amoeba may then penetrate the cribiform plate, a semiporous barrier, and spread to the meninges (the membrane surrounding the brain) and often to the brain tissue itself. The cribiform plate is more permeable in children, making them more susceptible to infection than adults. People with immune deficiencies may also be more prone to infection. The incubation period is usually 2 to 5 days, and the infection cannot be transmitted from person to person. In early studies, transmission by contaminated dust was suspected as an infection route but this has since been discounted as the organism does not survive desiccation.

N. fowleri meningitis causes non-specific symptoms such as fever, drowsiness, confusion, vomiting, irritability, high pitched crying and convulsions. Similar symptoms also occur in viral and bacterial forms of meningitis which are much more common than the amoebic form. Most cases of *N. fowleri*

meningitis are fatal, with only four survivors known among about 100 cases in the US since 1965.

Cases of disease have also been associated with swimming pools where disinfection levels were inadequate, and inhalation of tap water from surface water supplies that have been subject to high temperatures. The involvement of tap water supplies was first documented in South Australia, where a number of cases occurred in the 1960s and 70s in several towns served by unchlorinated surface water delivered through long above-ground pipelines. About half of the cases in the state did not have a recent history of freshwater swimming, but had intra-nasal exposure to tap water through inhaling or squirting water into the nose.

Investigators found *N. fowleri* in the water supply pipelines, and concluded that the high water temperatures reached in summer provided a suitable environment for growth of the organism. Tap water may also have been the primary source of infections attributed to swimming pools in these towns. The incidence of disease was greatly reduced by introduction of reliable chlorination facilities along the above-ground pipelines and introduction of chloramination in the 1980s led to virtual elimination of *N.fowleri* from the water supplies. Cases of disease have also been recorded in Western Australia, Queensland and New South Wales, and *N. fowleri* has been detected in water supplies in each of these states as well as the Northern Territory.

Prior to the incidents in Peoria, *N. fowleri* infections had not been reported to be associated with groundwater supplies. However as the organism may be found in moist soil, it is feasible that the amoeba may penetrate poorly constructed bores or be introduced by occasional contamination events. Warm water conditions and the absence of free chlorine may then allow it to proliferate in the system. Local health authorities in Arizona are continuing their investigation into the two deaths with assistance from CDC personnel. Plans are also underway to install a continuous chlorination plant on the groundwater supply, and some residents have called for the municipality to purchase the private water company and take over its operations.

UK Fluoride Research Priorities

The Medical Research Council of the UK has released a Working Group report on research needs on fluoride and health. The report was commissioned by the British Department of Health soon after the publication of a review by the University of York in September 2000[(1)]. This review examined the scientific evidence on fluoride and health, and concluded that:

- water fluoridation has a beneficial effect on tooth decay
- water fluoridation also increases the prevalence of dental fluorosis
- research carried out on possible non-dental health effects of fluoride was generally of poor quality and was limited in scope, making it difficult to interpret the results.

The MRC Working Group was therefore asked to identify and prioritise areas where research was required and where it could usefully inform public health policy, and also to consider how such research might best be undertaken. The Working Group made recommendations in six areas of research:

Total fluoride exposure and uptake

Investigation is needed to determine whether the bioavailability and absorption of fluoride differs from naturally and artificially fluoridated water, and how water hardness affects these aspects. If no differences are found between naturally occurring and artificially added fluoride, then observations of populations exposed to high levels of natural fluoride in water can provide valid information on the health effects of artificial fluoridation. However if substantial differences are found, then specific studies on bioaccumulation of fluoride from artificially fluoridated water will be required to determine whether this produces a risk of pathological changes within a reasonable lifespan in more than a small and defined minority of those exposed.

Better estimates of total dietary fluoride intake and the contribution of fluoridated water are also needed, as well as fluoride intake from other sources such as toothpaste. Such studies could be incorporated in the UK National Diet and Nutrition Survey.

Dental Caries

Studies are required to estimate the effect of fluoridation in children against a background of widespread use of fluoridated toothpaste, and the impact of fluoridation on caries occurrence in different social classes. The effects on recurrent caries in adults and root caries in older adults should also be assessed. Outcome measures should extend beyond customary measures of decayed, filled and missing teeth to include effects on quality of life and economic impacts.

Dental Fluorosis

Fluorosis prevalence in fluoridated and non-fluoridated areas needs to be carefully compared taking into account potential confounding factors and effect modifiers such as fluoridated toothpaste. Studies should also be undertaken on public perceptions of dental fluorosis, particularly the distinction between acceptable and aesthetically unacceptable fluorosis. Any prospective studies of dental caries incidence that are undertaken should also measure dental fluorosis.

Social Class

Studies on the effect of fluoridation in different social classes should include assessment of dental caries, dental fluorosis, fluoride from other sources, and dietary sugar intake.

Bone Health

If naturally and artificially fluoridated water are found to have different bioavailabilities, then a case-control study should be undertaken on hip fracture risks after long term exposure to artificially fluoridated water.

Cancer

An updated analysis of UK ecological data on water fluoridation and cancer rates should be undertaken.

Research on other potential health concerns raised in the literature was considered of low priority by the Working Group, as was research into indirect effects such as impurities in fluoridation chemicals, or leaching of metals from pipes or cooking utensils.

1) Reported in Health Stream Issue 20 - December 2000.

WHO Report On Home Water Management

The World Health Organisation has published a report reviewing methods for household water collection, treatment and storage, and their impact on microbiological water quality and diarrhoeal disease. The report summarises and assesses research in this area, and reviews information on the effectiveness, cost and community acceptability of interventions.

It is estimated that approximately 1.1 billion people do not have access to improved sources of water, and this is a major contributing factor to the high burden of illness and deaths from infectious disease in the developing world. Source water of acceptable microbiological quality may be contaminated by poor handling and storage practices, increasing infectious disease risks. While efforts continue to extend piped water supplies and adequate sanitation to those who lack these services, progress remains relatively slow. Water treatment and improved storage methods at the household level offer more rapid benefits to many communities, provided that such interventions are proven to be effective, affordable, and socially and culturally sustainable in the longer term.

The report initially reviews methods of water collection and the impact of storage vessel design and storage conditions. A brief overview is provided of physical and chemical water treatment methods, their availability and practicality, technical difficulty, cost and efficacy for removal of microorganisms. Five chapters then review the three major categories of water treatment, social and economic aspects, and monitoring the effectiveness of treatments.

Heat and UV radiation

- Bringing water to a rolling boil is effective in destroying all types of waterborne pathogens. Heating to lesser temperatures (eg 60 degrees C) then maintaining temperature for some time (equivalent to pasteurisation) may also be effective but is difficult to monitor reliably. In many parts of the world, the cost or scarcity of fuel makes boiling impractical as a routine method of water treatment.
- UV irradiation of water in clear plastic bottles using sunlight exposure has been demonstrated to be

effective in reducing the microbial content provided turbidity is less than 30 NTU. Aeration by shaking prior to sunlight exposure increases microbial killing. Epidemiological studies in Kenya have demonstrated reduced diarrhoeal disease in children with this system, and confirmatory studies are in progress. The system is low cost and simple to use.

- UV irradiation with lamps is also effective in reducing microbial content, but requires a reliable electricity supply, periodic cleaning and UV lamp replacement, and is of moderate to high cost. Energy costs are lower than for boiling water using wood or charcoal, and solar or wind powered systems are feasible in some situations. The system is most economic when applied at a community level rather than for individual households, however there have been no reported studies documenting its effect on illness rates.
- Solar thermal treatment using dark coloured vessels on a solar reflective surface for several hours can raise water temperatures to 65 degrees C or more, and inactivate most microbial pathogens. A simple wax pasteurisation indicator has been developed to indicate that an adequate temperature has been reached. This method is simple and low cost, but is limited by availability of sunlight.

Physical removal processes

- Larger microbes such as protozoa and helminth eggs can be reduced by more than 90% by simple sedimentation methods provided water is stored 1-2 days. Sedimentation is not reliable for reducing the numbers of smaller pathogens (bacteria and viruses), however it is a useful step for reducing turbidity and disinfectant demand prior to other treatments.
- Rapid filters using various types of granular media (sand, gravel, coal etc) may be used in a range of sizes from a 10 litre bucket size for a single household to large roughing filters serving whole communities. However microbial removal by such systems is generally only low to moderate, unless chemical treatment with positively charged salts (such as alum or iron) is used to prepare the filter media. Such treatments are too technically demanding to be practical at the household level.
- Slow sand filters are capable of high levels of microbial removal, however they have not been found to be effective at household level, probably due to their relatively large size, and requirements for proper construction, operation and maintenance. At a community level, these types of systems are appropriate for developing countries.
- Fibre and fabric filters have a long history but are not able to reliably remove most microbes, however they are effective for removal of specific larger pathogens such as guinea worm parasites, and phytoplankton and zooplankton harbouring *Vibrio cholerae* bacteria. Modern membrane filters may be very effective for removal of microbes (depending on pore size) but their costs and technical requirements make them impractical for use at the household level in developing countries.
- Porous ceramic filters have the capacity to provide a high degree of microbial reduction provided they are produced according to strict manufacturing requirements. A number of different types of locally produced ceramic filters and filter vessels are in use in developing nations but there are few data on their performance and reliability.
- Diatomaceous earth filters are considered unsuitable for household use because of their technical demands, difficulties with disposal of contaminated filter material and potential respiratory hazards from handling dry media.

Chemical water treatment

- Chemical coagulation, flocculation and precipitation is generally unsuitable for individual household use due to the technical skill required to achieve correct doses and mixing conditions. Coagulation using crushed seeds, nuts or other plant products has been traditionally used in some countries, but little is known about their effect on microbial contamination or potential toxicity.
- Adsorbents including charcoal, clay or burnt vegetable materials have been traditionally used for water treatment. Clay adsorption is unsuitable for household use due to difficulties in controlling adsorption of microbes and removal of the clay. Charcoal and other activated carbon media are not suitable for microbial reduction unless combined with chemical agents to enhance microbe removal.
- Ion exchange resins generally do not reduce microbial content and are not recommended for this purpose, except those used for iodine treatment of water. Such devices are effective for microbial

reduction but are too expensive for use in developing nations, and entail long term health concerns.

- Chemical disinfection with chlorine-based compounds was specifically developed to reduce risks from waterborne pathogens, and disinfection with ozone was developed some time later. These treatments are often used in combination with chemical coagulation, flocculation, sedimentation and/or filtration processes. There is substantial evidence that household chlorination of water effectively reduces rates of diarrhoeal illnesses, however chloramine, chlorine dioxide and ozone systems are too expensive and technically difficult to employ at the household level. Recently some trials have been undertaken with combined coagulant-flocculent-disinfectant systems designed for household use, with promising results.
- There is evidence that addition of lime juice to water and foods is effective in killing *Vibrio cholerae*, and reducing infection rates. Further research on this is recommended.

Social and Economic Aspects

- Successful implementation of water treatment requires social marketing to gain the involvement and acceptance of the community, and ensure ongoing participation. It is also important to assess the success of the implementation program. The costs of different types of water treatment are variable and may be influenced by local conditions and availability of materials. A range of approaches to funding have been undertaken, ranging from free provision of systems through to full cost recovery.

Monitoring and evaluating effectiveness

A number of aspects affecting the safety of home water treatment and storage can be defined and monitored to ensure effectiveness. These include the design, condition and cleaning of storage vessels; degree of turbidity reduction for coagulation and filtration treatments; water temperature reached for solar-based heating; chlorine residual and contact time for chlorine disinfection.

Managing Water in the Home: Accelerated Health Gains from Improved Water Supply. Available from: www.who.int/water_sanitation_health/Documents/WSH0207/managingwater.htm

News Items

Clean water benefits cattle too

Researchers studying the effect of water quality on cattle have found that animals supplied with clean water gained more weight than those drinking poor quality water directly from ponds. The 6-year Canadian study examined weight gain by yearling cattle and cows with calves. Yearlings gained 23% more weight drinking clean water compared to pond water, while calves gained 10% more weight. Those drinking pond water pumped to a trough had intermediate weight gains. There were no significant differences in the prevalence of faecal pathogens among the different groups of animals, so this was probably not a factor in weight differences. Cattle with higher quality water spent more time grazing and less time resting than cattle drinking pond water. The study suggests that excluding cattle from direct access to water sources can provide economic benefits to farmers as well as improving water quality by reducing faecal contamination and damage to the riparian zone.

Willms WD, et al. (2002) Effects of water quality on cattle performance. J. of Range Management **55**(5):452-460.

First drug approved for *Cryptosporidium*

The US Food and Drug Administration has approved a recently developed drug, nitazoxanide, for the treatment of *Cryptosporidium* diarrhoea in children from 1 to 11 years of age. Double-blind placebo controlled trials have shown the drug to be effective, with 88% of nitazoxanide-treated patients responding to treatment compared to 38% of controls receiving placebo. The drug is also effective against *Giardia* infections with results similar to the existing drug metronidazole. The drug company, Romark Laboratories, also has an application before the FDA for approval of nitazoxanide use in adults and HIV-infected people with *Cryptosporidium* diarrhoea.

Water bug link to gut diseases?

A US allergy researcher has suggested that copepods could be the cause of the chronic illnesses Crohn's disease and ulcerative colitis. These microscopic animals (1-2mm in length) are found in fresh and marine waters around the world and are one of the most abundant lifeforms on earth. Speaking at the

60th Annual Meeting of the American College of Allergy, Asthma and Immunology in San Antonio, Texas, Dr Steve Kagen reported that 44% of 75 patients being treated for allergies had antibodies against copepod proteins, and all patients with Crohn's disease tested to date (number unspecified) showed signs of allergy. He suggested that exposure to copepod proteins through drinking water and swimming may trigger development of these poorly understood inflammatory gastrointestinal conditions.

Bubbles are better for you

A study of the effects of carbonated water and tap water in people suffering constipation and dyspepsia has shown a significant improvement with the sparkling product. Italian researchers randomly assigned 21 patients to either of the two water types. Those drinking carbonated water for 15 days experienced significant reductions in symptoms and increased gallbladder emptying, although the speed of food movement though the colon was not changed. As the two types of water differed in mineral content as well as carbonation, it is not clear which characteristic may be responsible for the effects.

New Bathing Water Directive for Europe

The European Commission has announced its intention to revise the 25-year old Directive on Quality of Bathing Water. The new regulation will be similar to recent revisions to the World Health Organisation Guidelines for Safe Recreational-water Environments. Microbiological water quality of beaches will be classified on a 3-year trend with measurements of *E.coli* and intestinal enterococci, and a pro-active risk assessment and management approach will be required of EC Member States.

2003 Banksia Environmental Awards

The Banksia Environment Foundation is calling for entries for the 2003 Awards. The Awards are open to companies, businesses, governments and their agencies, consultants, researchers, educators, community groups and any individuals working on environmental initiatives. The initiative must be primarily undertaken in Australia, or must be shown to have a substantial environmental impact in Australia. More information: www.banksiafdn.com or email info@banksiafdn.com

From the Literature

Aluminium

Subacute fatal aluminium poisoning in dialyzed patients: post-mortem toxicological findings.
de Wolff F A, Berend K and van der Voet G B. Forensic Sci Int (2002) **128**(1-2) p41-3.

The Caribbean island Curacao has a high prevalence of end-stage renal disease, corresponding to 1 patient per 1000 population. Patients are chronically treated in three haemodialysis centres on the island. As other sources of drinking water are scarce, tap water on the island is produced by distillation of seawater with a small amount of calcium and fluoride supplemented. Haemodialysis fluid used to be prepared with tap water without other treatment.

In 1996, 27 patients in one dialysis centre showed symptoms of nausea, vomiting and hypercalcaemia. These symptoms are typical of “hard water syndrome” which can occur when patients are treated with a high-calcium (Ca) dialysate. Oral calcium carbonate and Vitamin D preparations were discontinued, however the symptoms continued to increase. Aluminium (Al) intoxication was then suspected and confirmed by the analysis of serum samples. Ten of the patient died from seizures, sepsis and coma. Serum samples had been taken from 7 of the 10 patients before they died. These all contained very high Al concentrations 808 ±127 micrograms/l. The survivors had serum concentrations of 255 ± 25 micrograms/l, which was significantly lower than the non-survivors ($P<0.01$).

A post-mortem toxicological analysis of liver, bone and cerebral cortex of four patients was undertaken and compared with background levels. Levels of liver, bone and cerebral cortex Al concentrations were extremely high in comparison to the reference values. Tap water sampled at the time the haemodialysis unit was closed was analysed and showed calcium concentrations of 18.1 mg/l and Al concentrations of 650 micrograms/l, these being much too high for dialysate.

A few weeks before onset of symptoms, a water conduit pipe to the dialysis unit had been replaced. The new pipe was lined with Al- and Ca-rich cement mortar to protect against corrosion. These ions leached into the water and caused both Ca- and Al-intoxication of patients through uptake from dialysate into their circulation. The finding of high Ca levels in patients meant that the underlying Al intoxication was not initially recognised.

Comment *Dialysis patients are extremely vulnerable to contamination of dialysate fluid as substances in the fluid can directly enter the bloodstream. Modern dialysis facilities generally use multistage water treatment including reverse osmosis filters to purify tap water prior to use, and monitor the dialysate quality frequently.*

Aluminium content of drinking waters, fruit juices and soft drinks: contribution to dietary intake.
Lopez F F, Cabrera C, Lorenzo M L, et al. Sci Total Environ (2002) **292**(3) p205-13.

The levels of aluminium (Al) were determined in 176 samples of drinking water, fruit juices and soft drinks widely consumed in Spain. Graphite furnace atomic absorption spectrometry was used to measure concentrations. The influence of the type of container on Al content of these beverages was also evaluated.

It was found that soft drinks have a higher mean level of Al than fruit juices and drinking water. There was a high variability in the Al content within each of the beverage groups. The Al levels ranged from 4.2 to 134.1 micrograms/l in tap water samples collected at different locations in Granada Province. Commercial bottled water samples had Al concentrations ranging from 15.9 to 165.3 micrograms/l. The mean Al concentration in glass bottle samples was 57.6 micrograms/l, whereas samples from plastic bottles had a mean of 165.2 micrograms/l. The highest level of Al was found in the sparkling mineral water samples (mean 143.8 micrograms/l). In fruit juices, Al concentrations ranged from 49.3 to 1144.6 micrograms/l. The highest levels were found in some samples of tomato juices and in canned samples. In soft drinks, Al concentrations ranged from 44.6 and 1053.3 micrograms/l. Most of the elevated concentrations were found in some canned samples of orange and lemon soft drinks. The dietary intake of Al from water, fruit juices and soft drinks was estimated to be 156 micrograms/person/day. The results found here contribute useful new data on Al content of a variety of foods and beverages in Spain.

Arsenic

Toxicology Letters - Special Issue on Arsenic
Vol **133** (1) July 7th 2002, edited by Dr JC Ng.

This special journal issue comprises eleven papers which provide a snapshot of knowledge on arsenic toxicology and current research approaches to this issue. The contributions include:

- a review of arsenic toxicity and potential methods of action. Arsenic can exist in inorganic and organic forms and four different valency states. These various forms are metabolised differently and produce a range of metabolic intermediates. It has been generally thought that methylation of arsenic reduces toxicity, but recent research has shown some methylated derivatives are more toxic than their parent compounds. The complexity of arsenic metabolism opens the possibility that it may exert adverse effects by more than one mechanism.

- a review of animal models for the study of arsenic carcinogenesis. A variety of animal models have been used to study cancer induction by arsenic but most have failed to clearly demonstrate carcinogenicity, although some have shown that arsenic can promote the growth of tumours induced by other chemicals. However, human epidemiological evidence suggests that exposure to inorganic arsenic alone is sufficient to cause cancer, so efforts have continued to find an animal model that parallels this effect. A mouse model has now been described which has shown tumour formation in multiple organs when mice were chronically exposed to drinking water with inorganic arsenic levels equivalent to those in highly exposed human populations in Bangladesh and West Bengal. This may provide a means to elucidate the mechanism of arsenic action in humans and permit better assessment of chronic health risks.

Three papers describe evidence for possible modes of action of arsenic carcinogenesis:

- effects on signal transduction pathways that are involved in cellular protective and repair functions in response to stress
- generation of reactive oxygen species (free radical molecules) that can cause DNA damage
- inhibition of DNA repair after damage by other chemicals

There is also a review of evidence in a relatively new area of health concern:

- possible links between arsenic exposure and development of diabetes mellitus. Six studies carried out in Taiwan, Bangladesh and Sweden have suggested this association.

Three papers in the collection examine various aspects of arsenic metabolism:

- a human volunteer study showing absence of interaction between absorption and excretion of arsenic and fluoride. This contradicts some prior reports suggesting that the two elements may interact with each other.
- arsenic species in the urine of human subjects and the effect of seafood consumption
- assessment of a potential biomarker of arsenic exposure in rodents.

The collection finishes with two papers examining methods of removing arsenic from drinking water:

- the effects of various anions on removal of arsenic from drinking water by iron hydroxides
- arsenic removal using advanced oxidation processes.

Toxicology Letters is published by Elsevier Science: www.elsevier.com/locate/toxlet

Bottled Water

Bacterial water quality in the personal water bottles of elementary students.
Oliphant J A, Ryan M C and Chu A. Can J Public Health. Revue Canadienne de Sante Publique (2002) **93**(5) p366-7.

This study examined the bacteriological water quality in personal water bottles used by students at a school in Calgary, Canada. Representative samples of water that the students were drinking were collected from three separate classrooms over a one-week period. A total of 76 samples of water from the student's bottles were taken with samples ranging from 10 to 500 ml. Samples of source water from each of the three classroom sinks and from two drinking water fountains in the school hallways were also taken. Water samples were analysed for heterotrophic bacteria and total and faecal coliform bacteria.

Ten (13.3%) of the 75 water samples analysed contained >10 cfu/100ml total coliforms. Six (8.9%) of the 68 samples analysed for faecal coliforms had > 1 cfu/100ml. Heterotrophic bacteria concentrations of >500 cfu/ml (exceeding the drinking water guidelines) were found in 64.4% of the 76 samples analysed. Heterotrophic plate counts are used as an overall indicator of bacterial quality of water supplies. All samples from the five tap water sources were under the detection limits for total and faecal coliforms and heterotrophic bacteria.

The findings show that significant bacterial contamination can occur in individual water samples from personal water bottles. The most likely source of the bacteria is from improper hand washing by the students after using bathroom facilities which can result in faecal coliforms in the classroom area. The students from this school may be safer drinking from water fountains than drinking from water bottles. Students need to be educated about hygiene practices to decrease the spread of coliform bacteria.

Comment Neither HPC nor total coliform bacteria are considered as specific indicators of health risk, however faecal coliforms are a more specific indicator of concern.

Survey of bottled drinking waters sold in Canada for chlorate, bromide, bromate, lead, cadmium and other trace elements.
Dabeka R W, Conacher H B S, Lawrence J F, et al. Food Add Contamin (2002) **19**(8) p721-32.

A survey was undertaken in Canada of bottled drinking waters, including mineral, spring and other bottled drinking water (distilled waters, flavoured waters, reverse osmosis water etc). The levels of trace elements and other toxic chemicals were analysed in 199 samples of imported and domestic bottled (and canned) water sold in 1995-96. Three bottles of the same lot of each type of packaged water sold in Canada were purchased. One of the three bottles was analysed for contaminants.

The bottled water was surveyed for chlorate, bromide, bromate, Cr(VI), Li, B, Al, Mn, Cu, Zn, Sr, Ba, Be, V, Cr, Co, Ni, As, Se, Mo, Ag, Cd, Sb, Tl, Pb, Na, K, Ca and Mg. Various methods were used to determine the concentrations of the trace elements and chemicals. Ion chromatography (IC) with conductivity detection was used to determine chlorate and bromide concentrations. Cr(VI) was determined by IC with colorimetric detection, bromate by solvent extraction and gas chromatography, trace elements by inductively coupled plasma mass spectrometry and Na, K, Ca and Mg by flame atomic absorption spectrometry.

The analysis demonstrated that the majority of the chemicals surveyed were within national and international drinking water guidelines. Of the 199 samples examined, 22% exceeded either the Canadian and/or WHO guidelines for one or more of the following elements: B (22 samples), Al (9), Mn (5), Cr (1), Ni (1), As (10), Se (24) and Pb (1). Three distilled water products had high concentrations of Cu and Ni, probably caused by contamination during distillation. In two imported mineral waters high Li levels were detected (575 and 890 micrograms/L). Ingestion of 350 mls of the latter would overlap with the therapeutic doses of Li prescribed for depressive and bipolar disorders, thus people on Li medications could risk overdosing when drinking this water.

Cancer

Community cancer assessment in response to long-time exposure to perchlorate and trichloroethylene in drinking water.
Morgan J W, Cassady R E. J Occup Environ Med (2002) **44**(7) p616-21.

Concerns about contamination of ground and drinking water with trichloroethylene (TCE) and ammonium perchlorate prompted a request for an assessment of the observed and expected numbers of new invasive cancer cases. The assessment was undertaken within a collection of 13 contiguous census tracts encompassing the city of Redlands, San Bernardino County, California. Studies have suggested that perchlorate contamination of some Redlands wells may have occurred as early as 1980 and TCE contamination as much as ten years earlier.

New invasive cancer cases diagnosed between January 1, 1988 and December 31, 1998 were included in the assessment. A total of 16 types of cancers were included. The number of cancer cases expected to occur among residents of the 13 census tracts during 1990 was estimated taking into account the age, race/ethnicity and gender distribution of the population. The number of new invasive cancer cases observed among residents of the 13 census tracts from 1988 through 1998 was obtained from the Desert Sierra Cancer Surveillance Program database. Standardised incidence ratios (SIRs) were calculated for each of the cancer sites by dividing the observed number of new invasive cancer cases by the growth-adjusted expected number of cases aggregated for the 13 census tracts over the 11 years studied.

The observed numbers of new cancer cases with origins in the lung and bronchus (SIR, 0.71; 99% CI, 0.61 – 0.81) and the colon and rectum (SIR, 0.86; 99% CI, 0.74 – 0.99) were statistically significantly lower than the numbers expected. These findings are consistent with what might be expected for a population having lower than average tobacco use and receiving better than average cancer screening. The number of melanomas of the skin (SIR, 1.42; 99% CI, 1.13 – 1.77) and malignancies with origins in the corpus uterus (SIR, 1.35; 99% CI, 1.06 – 1.70) were significantly higher than the number expected. These findings are consistent with the relatively high socio-economic status of this population. The increased access to health care means that low-grade melanoma lesions are detected and reported. The use of oestrogen replacement therapy is also more common among women receiving better access to health care and has been linked to elevated risk of

uterine cancer. For childhood cancer, none of the finding showed any significant differences from observed numbers of new cancer cases than from the numbers of expected cases. This was also true for all cancers combined (SIR, 0.97; 99% CI, 0.93 – 1.02), thyroid cancer (SIR, 1.00; 99% CI, 0.63 – 1.47) and all other cancer types studied. The authors conclude that the observed pattern of cancer occurrence is consistent with the sociodemographic and lifestyle characteristics of the population, and did not indicate any generalised increase in cancer or specific increase in thyroid cancer (suggested as a possible effect of perchlorate exposure).

Disinfection Byproducts

Risk of specific birth defects in relation to chlorination and the amount of natural organic matter in the water supply.
Hwang B F, Magnus P and Jaakkola J J K. Am J Epidemiol (2002) **156**(4) p374-82.

The effect of water chlorination by-products on specific birth defects, particularly defects of the neural tube and urinary tract were assessed in a nationwide cross-sectional study of all births occurring from 1993-1998 in Norway. The role of natural organic matter in nonchlorinated waters was also investigated.

The final study population included 184,676 infants registered by The Norwegian Medical Birth Registry from 1993 to 1998. The effect of chlorination by-products on the risk of any birth defect and on neural tube, cardiac, respiratory system, urinary tract and oral cleft defects were assessed. Exposure assessment was based on municipal-level water quality information on chlorination practices and the humic content of raw water and the mother's place of residence during pregnancy. The waterworks serving the municipalities were divided according to their use of chlorination disinfection and by water colour, which is a measure of dissolved organic compounds (i.e. high colour = high dissolved organic compounds). Exposure categories were constructed by using chlorination and three levels of colour: low (0-9.9 mg Pt/litre), medium (10-19.9 mg Pt/litre) and high (>=20 mg Pt/litre). Low colour with no chlorination served as the reference category. The three levels of colour without chlorination were used to examine the effects of natural organic matter.

Of the livebirths in the study population, there were 5,764 with birth defects of interest. The risk of any birth defect was higher in the chlorination and medium-colour (adjusted odds ratio (OR) = 1.11, 95% confidence interval (CI): 0.99,1.24) and high-colour (adjusted OR = 1.18, 95% CI: 1.02, 1.36) categories than in the reference category, showing an exposure-related increase. There was no consistent association of chlorination and colour with neural tube defects. The risk of neural tube defects was related to colour without chlorination (adjusted OR = 2.60, 95% CI: 1.30,5.26) in the high-colour category.

For cardiac defects the risk estimate for the combined medium- and high-exposure categories was statistically significant (adjusted OR = 1.37, 95% CI: 1.00, 1.89) although each individual category was not. The risk of ventricular septal defects was significantly high, with an exposure response pattern showing an adjusted OR of 1.63 (95% CI: 1.02, 2.58) for the medium and 1.81 (95% CI: 1.05,3.09) for the high exposure category. For respiratory system defects the risk estimate for combined medium- and high-exposure categories barely reached statistical significance (adjusted OR = 1.89, 95% CI: 1.00, 3.58) and the individual categories did not. None of the estimates for oral cleft defects reached statistical significance. The risk estimate for urinary tract defects for combined medium- and high-exposure categories was 1.46 (95% CI: 1.00, 2.13).

The authors conclude that the results of this study support the view that prenatal exposure to chlorinated surface waters containing elevated levels of natural organic matter increases the risk of birth defects, with small increases in urinary tract, respiratory system and major cardiac defects. The results also suggest that natural organic matter in nonchlorinated tap water contains substances that may increase the risk of neural tube defects.

Comment About half of all births were excluded from the study due to insufficient water quality data. As this was a registry-based study, it was not possible to

assess maternal mobility during pregnancy, water consumption, or potential confounders such as alcohol consumption, smoking, vitamin use, medication or environmental or occupational exposures. Some of these unmeasured factors may have significant effects on the risk of birth defects.

Swimming and Birth Weight
Nieuwenhuijsen M J, Northstone K and Golding J. Epidemiology (2002) **13**(6) p725-8.

Some studies have suggested that exposure to chlorination disinfection byproducts may increase the risk of having a low weight baby. Swimming is recommended exercise for pregnant women, however some swimming pools have been found to contain high levels of trihalomethanes which are byproducts of chlorination disinfection. The relationship between swimming and birth weight was examined in a large birth cohort, the Avon Longitudinal Study of Parents and Children (ALSPAC) in the UK.

Women who were expected to deliver between 1 April 1991 and 31 December 1991 and who were a resident of a defined geographical area of Avon in Southwestern England were eligible for this population-based cohort study. A question on antenatal activity was sent to women at 18-20 weeks gestation. Women were asked to report the number of hours they swam per week.

There were 11,462 pregnant women for which information on the duration of swimming was available. Most women (59%) reported than they never swam, 31% swam up to 1 hour per week, and 10% swam for longer. Multiple linear regression was used to examine the relationship between birth weight and duration of swimming with adjustment for gestational age, maternal age, parity, maternal education level, ethnicity, housing tenure, drug use, smoking and alcohol consumption. There was no significant trend found for amount of swimming and birth weight. There was an increase in gestation length with an increase in the amount of swimming, and a slight increase in birth weight. There was a dose-response effect found for smoking and amount of swimming. The more women smoked, the less likely they were to swim. Women who were more highly educated were more likely to swim, and a relationship between educational level and duration of swimming was apparent.
This study found little effect of the amount of swimming by pregnant women and birth weight of their children even though levels of THMs in swimming pools have been reported to be high and studies have suggested the potential uptake of THMs from swimming may be high.

Comment Disinfected swimming pools would be expected to contain disinfection byproducts from the tap water used to fill the pool, plus a range of byproducts formed by reaction of pool disinfectant with organic material in the pool water. Swimmers are likely to have high exposure to volatile disinfection byproducts by inhalation, and to lipophilic byproducts by absorption through the skin, in addition to inadvertent ingestion of pool water.

Endotoxins

A review of drinking-water-associated endotoxin, including potential routes of human exposure.
Anderson W B, Slawson R M and Mayfield C I. Can J Microbiol (2002) **48**(7) p567-87.

Endotoxins are part of the outer membrane of the cell wall of Gram-negative bacteria and some cyanobacteria. These substances are normally released upon cell lysis and during multiplication. Humans exposed to endotoxins may have symptoms that include fever, diarrhoea and vomiting, hypotension and shock, intravascular coagulation and death. The most severe symptoms only occur when concentrations in the body are elevated onto the range of milligrams per kilogram of body weight, as sometimes happens in serious bacterial infections. Fever is a very common symptom at lower concentrations. This review examines documented drinking water associated incidents of endotoxin exposure that can be attributed to hemodialysis and inhalation exposure. Endotoxins are not readily absorbed via the digestive tract, so ingestion exposure is not considered significant.

The potency of endotoxins in humans in terms of pyrogenicity (fever production) depends on the type and species of organism from which the endotoxin originates. The available evidence suggests that

cyanobacterial endotoxins are generally not as potent in terms of pyrogenicity as those of gram-negative bacteria. During hemodialysis or by inhalation of aerosolised water droplets the minimum amount of endotoxin that would have to pass into the bloodstream to induce fever (a 1.9 degree C increase in body temperature) is calculated at 0.002-0.280 micrograms/individual (corresponding to a body weight range of 1 - 140 kg). Doses as low as 9 ng/m^3 of inhaled endotoxins may induce a measurable change in lung function. Populations which are exposed to a specific endotoxin over a long period of time, may develop immunity to that endotoxin but would not be immune to other endotoxins. The medical literature contains a number of reports of illness due to endotoxin exposure from water, including outbreaks of fever among dialysis patients, and fever plus respiratory symptoms among people exposed to water vapour from humidifiers, spa baths and other aerosol generating equipment. In one outbreak, endotoxin appeared to be strongly implicated in the death of a dialysis patent.

Data on endotoxin in drinking water are scant but suggest that concentrations are typically less than 10 nanograms/ml. Elevated endotoxin levels can occur when high raw water levels are not adequately reduced during drinking water treatment or contamination of open finished water storage reservoirs occurs with gram-negative bacteria or cyanobacteria. The water treatment processes of coagulation, flocculation and sedimentation provide considerable removals of endotoxins, possibly in the order of 60-90%. The concentrations and contact times of oxidation or disinfection used in drinking water treatment may not be effective for endotoxin removal. From the limited information available, biological treatment in general does not produce higher endotoxin levels than conventional treatment.

Some of the recommendations made from this review include: the need to quantify the importance of human exposure to endotoxins via inhalation and ingestion, the need for additional surveys to be conducted to determine typical levels of endotoxins in raw water and following treatment and distribution of drinking water, the need to define the health risks associated with typical and extreme levels of endotoxins in drinking water, and the need for alternative removal technologies to be identified.

<u>Comment</u> The documented incidents of illness described in this review appear to relate to circumstances where gram-negative bacteria have grown to high levels in niches beyond the tap water supply and aerosols have been subsequently generated, eg humidifiers, spas, high pressure cleaning sprays using recycled water, or where dialysis has been performed without adequate pre-treatment of tap water to remove contaminants.

<u>Metals</u>

Effect of coagulant treatment on the metal composition of raw water.
Fatoki O S, Ogunfowokan A O. Water SA (2002) **28**(3) p293-7.

Two coagulants were investigated to determine their ability to reduce metal levels (Cd, As, Cr, Ni, Mn, Cu and Zn) of raw river water samples. Raw water samples were taken from the Tyume River in Alice, South African which receives agricultural runoff and sewage effluent. The water samples were coagulated with different doses of $Al_2(SO_4)_3$ and $Fe_2(SO_4)_3$ (3, 5, 6, 8 and 10 mg/l of coagulant). After the coagulant treatments the change in concentration of Cd was not very significant and the final concentrations were still higher than the South African water quality guideline of 5 micrograms/l Cd. Significant removal of Cr occurred using both coagulants but removal was much more significant using $Fe_2(SO_4)_3$ treatment and fell within the South African guideline of 0.05 mg/l for water intended for domestic use. The removal of As in water by either coagulant was very small and not significant. The level of As after treatment was still higher than the guideline value of 10 micrograms/l. The percentage of Ni removal by $Fe_2(SO_4)_3$ was very significant, nevertheless there is no guideline for Ni in water for domestic use in South Africa. Removal of Mn from water by $Fe_2(SO_4)_3$ was significant, although the level was still higher than the 0.05 mg/l guideline value. The level of Cu in river water after coagulant treatments was close to the South African water quality guideline of 1.0 mg/l Cu. Removal of Zn was very significant and after $Fe_2(SO_4)_3$ treatment and was much less than the South African water quality criterion of 3.0 mg/l.

In general the percentage removal of the metals from the raw water samples increased with mg/l dosage of coagulant used. $Fe_2 (SO_4)_3$ was the more efficient coagulant for the removal of all metals. The authors suggest the use of $Fe_2 (SO_4)_3$ as a coagulant in water treatment has much potential, given the possible health concerns over alumnium in potable water.

Microsporidia

Low- and medium-pressure UV inactivation of microsporidia Encephalitozoon intestinalis.
Huffman D E, Gennaccaro A, Rose J B, et al. Wat Res (2002) **36**(12) p3161-4.

Microsporidia are emerging pathogens that are increasingly being recognised in immunocompetent as well as immunosuppressed hosts. This small organism is hard to remove with conventional filtration techniques found in many drinking water treatment plants. Microsporidia are also very stable in the environment with several species staying infective for months to years outside their hosts. This paper looks at the ability of low- and medium pressure UV light to inactivate microsporidia *Encephalitozoon intestinalis* spores.

Replicate cell culture analyses were carried out using three UV doses (3, 6 and 9 mJ/cm^2) for both low- and medium-pressure UV. UV treated samples and controls (these were not exposed to UV light) were analysed using a modified foci detection method-most probable number (FDM-MPN) cell culture technique. The control spores of *E. intestinalis* had a mean percent infectivity of 2.1% ± 0.3% with an average MPN/ml of 8.1 x $10^{3.}$ The spores that were exposed to either low- or medium-pressure UV doses of 6 and 9mJ/cm^2 showed no infectious foci in any of the cell monolayers yielding greater than 3.9 $\log_{10}$ inactivation of *E. intestinalis*. Spores exposed to a low- or medium-pressure dose of 3 mJ/ cm^2 showed an inactivation of 1.6-2.0 $\log_{10.}$

Microsporidia is on the USEPA candidate contaminant list as potentially requiring regulation and monitoring. This study demonstrates that UV light at dosages used for treating drinking water can effectively inactivate microsporidia *E. intestinalis.*

Nitrate

A nested case-control study of methemoglobinemia risk factors in children of Transylvania, Romania.
Zeman C L, Kross B and Vlad M. Environ Health Perspect (2002) **110**(8) p817-22.

This nested case-control study investigated the risk factors for methemoglobinemia (MGH) in 5-year-old children in the Transylvania region of Romania. MGH is a condition in which the haemoglobin molecule is oxidised to an abnormal form, making it unable to carry oxygen effectively to the tissues. The relationship between nitrate/nitrite exposure as a risk factor for MHG and other risk factors such as diarrheal disease was examined. Exposures were calculated as continuous values (reported in milligrams per kilogram per day) of nitrate/nitrite based on all dietary sources and environmental sampling. This allowed comparison of point estimates of nitrate/nitrite exposure with other continuous, categorical and ranked risk factors such as the presence or absence of diarrheal disease, reported severity of diarrheal disease, the use of vitamin supplements, the presence, absence and /or duration of breast-feeding and whether or not first-generation relatives experienced MHG.

Cases and controls were located from records in the district physicians' office coordinated through the Sanitary Police Headquarters for each of six selected counties in Romania. Cases of known infantile MHG meeting the inclusion criteria were recruited. Controls who met the inclusion criteria were selected randomly. Interviews were conducted in person with the primary caregiver acting as proxy for the child. After the interview a yard and well inspection was undertaken and environmental and biological samples were collected as necessary.

Controls had a more diverse choice of water source and cases had significantly higher nitrate in their potable water than did controls. Greater than 90% of controls boiled their water for infant formula preparation compared to 79% of cases. Univariate and multifactorial analysis of risk factors for MHG for this population showed that MHG is most

strongly associated with nitrate/nitrite exposure through the dietary route (p = 0.0318), via feeding of formula and tea made with water with high levels of nitrates. It was also found that breastfeeding protects infants under 6 months from diarrheal disease (p = 0.0244). The use of vitamin supplements was mildly protective in this group, however the sample size was small. Cases and controls in the high-nitrite/nitrate exposure category differed from each other in that, controls were less likely to have experienced severe diarrhoea and were more likely to have been breast fed for more than 2 weeks. the authors suggest that diarrheal disease may contribute to MHG in a subgroup of children and that further study is needed to understand this relationship and any contributing or confounding factors that influence it.

Water Hardness

Association of very low birth weight with calcium levels in drinking water.
Yang C Y, Chiu H F, Chang C C, et al. Environ Res (2002) **89**(3) p189-94.

It has been hypothesised that calcium supplementation during pregnancy can reduce smooth muscle contractility and tone which results in a reduction in blood pressure. If uterine smooth muscle contractility is reduced by calcium supplementation then a lower incidence of premature delivery would be expected. This study examined the relationship between the levels of calcium in drinking water and the risk of delivering a child of very low birth weight (VLBW).

Information on the level of calcium in 252 municipalities in Taiwan was obtained from the Taiwan Water Supply Corporation. Study subjects were all first-parity live-born, singleton infants born between January 1, 1993 and December 31, 1997 in the 252 municipalities. Cases were all VLBW births (less than 1500g). Controls were all other births with the exception of babies who weighed between 1500 and 2499g. Controls were randomly pair-matched with cases by sex, month and year of birth. The municipality of residence for all cases and controls was identified from birth certificates and was assumed to be the source of the subject's calcium exposure via drinking water. There were 540,703 births included in the final analysis.

There were 1781 VLBW cases included in the study. The mean calcium concentration in the drinking water of cases was 32.07 mg/L and 33.49 mg/L for the controls. For the group with the highest calcium levels (>= 42.2) the crude odds ratios (ORs) were significantly lower than 1.0 (0.83, 95% CI= 0.72-0.97) for VLBW. After adjustment for possible confounders (maternal age, marital status, maternal education, urbanisation level and baby gender), adjusted ORs were also significantly lower than 1.0 for the group with the highest calcium levels (0.81, 95% CI= 0.69-0.96). There was a significant trend found toward a reduced risk of having a child of VLBW with increasing calcium levels in drinking water (x^2 for linear trend = 5.56, P<0.05).

There was a significant protective dose-response effect of calcium intake from drinking water on the risk of having a VLBW baby. This protective effect was found in the group with the highest levels of calcium intake; therefore it may be that only subjects with calcium intake via drinking water above a certain level have a reduced risk of VLBW.

Comment This study did not assess water intake by women or factors that may affect birth weight such as smoking, drug use, maternal nutrition (including calcium intake) etc.

Drinking water and cardiovascular disease [Review]
Sauvant M P, Pepin D. Food Chem Toxicol (2002) **40**(10) p1311-25.

This review examines the relationship between cardiovascular disease (CVD) mortality and hardness of drinking water (DW). Ecological, case-control and cohort studies published between 1960 and 2000 were reviewed. There were 19 ecological studies, 5 cohort studies and 6 case-control studies. The majority showed a significant negative relationship between CVD mortality and DW hardness.

Most of the first group of ecological studies considered were performed from 1960 to 1980 using

mortality data from national registers with the units of analysis being geographical areas defined from an administrative basis. There are some limitations to these studies in that they are performed with average values of DW parameters (total hardness, calcium and/or magnesium contents); this may lead to substantial non-differential classification. The DW mineral content was often determined at the time of the study after the CVD event and may not truly represent the quality of the drinking water the person ingested before their death. Information on methodology is not always well recorded and confounding factors often were not considered in these studies. In the last decade considerable progress in epidemiological methodology has been made and ecological studies have been performed on very large populations living in specific geographical areas.

There have been several significant relationships found between CVD morality or morbidity and DW hardness in some cohort studies based on exposure status in England and Wales, Finland and the USA. Confounding factors were more likely to be considered in these studies however, not all important influences on CVD mortality were examined and the amount of ingested DW was not detailed. Comparing results from these studies is difficult because classification and cut-off levels for "soft" and "hard" water vary greatly. The case-control studies reviewed which are based on outcome status are not numerous but they have shown that lower CVD mortality or morbidity rates are associated with areas with hard water and higher mortality in areas with soft water. A very large study in Taiwan found a significant and dose-dependent protective effect of magnesium intake from DW on the risk of CVD.

The relationship between DW and CVD mortality is supported by a large number of studies but a causal link has not been defined. Further research is required to distinguish which bulk and/or trace elements can be implicated in the pathogenesis of CVD. Large intervention studies are needed which integrate all the cardiovascular risk factors in order to identify the attributable risk of DW in relation to CVD.

<u>Comment</u> The protective effect of hard drinking water was also seen in a case-control study of heart attack mortality (reviewed in Health Stream Issue 20 - December 2000).

Calcium nephrolithiasis: Effect of water hardness on urinary electrolytes.
Schwartz B F, Schenkman N S, Bruce J E, et al. Urology (2002) **60**(1) p23-7.

The aim of this study was to analyse the contribution of water hardness from public water supplies on calcium stone incidence and 24-hour urine chemistries in patients who form calcium stones. Many residents of areas with hard water believe that the increased mineral content, in particular calcium, increases their risk of developing urinary stones.

Concentrations of more than 200 minerals and other organic compounds in monitored water supplies were provided by the USEPA. Drinking water hardness was divided into decile rankings. Patients with a history of calcium stones were identified from a national database and given a standardised questionnaire and 24-hour urine chemistries were evaluated. Exposure to hard water was based on the zip code of the patient's residence. Calcium, magnesium and total water hardness were selected as independent variables. There were 3270 patients included in the analysis. The total number of lifetime stone episodes was similar between patients living in areas with a soft public water supply and those from areas with a hard public water supply. Mean lifetime stone episodes were 3.4 in the softest water decile area compared with 3.0 stone episodes in the hardest water decile area. There was no significant difference between these rates, nor when magnesium content alone or calcium content alone where compared. The amount of 24-hour urine calcium, magnesium and citrate excretion varied directly with drinking water hardness. There were no significant changes observed in urinary oxalate, uric acid, pH or volume with water hardness.

The results found here indicate no association between water hardness and the incidence of urinary stone formation. A correlation between water hardness and urinary calcium, citrate and magnesium levels was seen although the significance of this is not known.

Additional Articles

Toxins and bioactive compounds from cyanobacteria and their implications on human health.
Rao P V L, Gupta N, Bhaskar A S B, et al. J Environ Biol (2002) **23**(3) p215-224.

Disease Transmission Models for Public Health Decision Making: Analysis of Epidemic and Endemic Conditions Caused by Waterborne Pathogens.
Eisenberg J N S, Brookhart M A, Rice G, Brown M and Colford J M J. Environ Health Perspect (2002) **110**(8) p783-90.

Work related symptoms among sewage workers: a nationwide survey in Sweden.
Thorn J, Beijer L and Rylander R. Occup Environ Med (2002) **59**(8) p562-6.

Constructing Scientific Authorities: Issue Framing of Chlorinated Disinfection Byproducts in Public Health.
Driedger S M, Eyles J, Elliott S D and Cole D C. Risk Anal (2002) **22(**4) p789-802.

Outbreaks in drinking-water systems, 1991-1998.
Craun GF, Nwachuku N, Calderon RL, Craun MF. Journal of Environmental Health 2002;**65**(1):16-23.

Assessing the Exposure of Pregnant Women to Drinking Water Disinfection Byproducts.
Barbone F, Valent F, Brussi V, Tomasella L, Triassi M, Di Lieto A, Scognamiglio G, Righi E, Fantuzzi g, Casolari L and Aggazzotti G. Epidemiology (2002) **13**(5) p540-44.

Environmental risk factors of young onset Parkinson's disease: a case-control study.
Tsai C H, Lo S K, See L C, Chen H Z, Chen R S, Weng Y H, Chang F C and Lu C S. Clinical Neurology and Neurosurgery (2002) **104**(4) p328-33.

Zero exposure - a goal for environmental and occupational health?
Aitio A. Toxicology Letters 2002;**134**(1-3):3-8.

Analysis of transmission pathways of Pseudomonas aeruginosa between patients and tap water outlets.
Reuter S, Sigge A, Wiedeck H, Trautmann M. Critical Care Medicine 2002;**30**(10):2222-2228.

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 CRC, and information about other CRC 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 CRC.

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

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

Phone +61 (0)3 9903 0592
Fax +61 (0)3 9903 0576
Email pam.lightbody@med.monash.edu.au

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