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## Sydney Water Inquiry Continues

The Sydney Water Inquiry is continuing its investigations into the protozoa contamination incidents which affected Sydney during July, August and September. Since our last edition the Inquiry has produced a third interim report dealing with the contamination events and catchment management. A fourth interim report covering the contractual arrangements for the Prospect water treatment plant, and a final report summarising the findings of the Inquiry and recommendations for the future will follow soon.

The New South Wales state government has already passed legislation to implement some of the Inquiry's recommendations, including the establishment of a Catchment Authority with the power to veto developments that threaten water quality. The Catchment Authority will assume control of Sydney's catchments, dams and treatment plants in a move that will greatly reduce the role of Sydney Water Corporation. Under the new arrangements, Sydney Water Corporation will retain responsibility only for water distribution and for sewage collection, treatment and disposal.

The final report of the Sydney Water Inquiry is expected to have far reaching effects, not only for the management of *Cryptosporidium* and *Giardia* in water supplies, but also on the regulatory environment for the Australian water industry.

The CRC for Water Quality and Treatment has joined other leading industry bodies in providing information to the Sydney Water Inquiry, and promoting better understanding of the issues to the public, media and government. The combination of public health and water management expertise within the CRCWQT places it in a unique position to address these complex problems, and to develop and

Editor Martha Sinclair  
Assistant Editor Pam Lightbody

## CRCWQT Internet address:

<http://www.waterquality.crc.org.au/>

advocate rational and cost-effective solutions to ensure the protection of public health.

**Third Interim Report: Assessment of the contamination events and future directions for the management of the catchment.** (delivered on 28th October)

The main findings can be summarised as follows:

Deficiencies in Catchment Management The Inquiry found that the main catchment from which Sydney draws its drinking water has been seriously compromised over a prolonged period of time.

The Warragamba catchment is divided into two zones, with the inner catchment comprising about 3,500 square kilometres and the outer catchment about 6,000 square kilometres. The inner catchment is largely closed to public access but contains substantial areas of freehold land used for cattle grazing, mining and several residential developments. The outer catchment contains several major cities and many medium and small towns, as well as mines and agricultural lands.

There are many potential sources of human and animal faecal pollution in both the inner and outer catchment areas, as well as sources of other types of pollutants. Activities in the catchment are regulated by a large number of government and non-government organisations and this has resulted in fragmented responsibilities, and lack of clear accountabilities. There are at least 50 statutes affecting water quality in New South Wales and these are administered by nine major bodies plus many local authorities. There is no single body with overall responsibility to minimise raw water contamination, and poor coordination of decision making by different bodies. Significant deficiencies and lack of coordination in catchment management have been identified in a number of reviews dating back as far as 1984.

While some initiatives to improve catchment management had already been taken prior to the recent incidents, the Inquiry believes that urgent action is required to protect Sydney's water supply. The Inquiry has recommended the formation of a Catchment Commission, and the development and

implementation of a new Regional Environmental Plan by the Department of Urban Affairs and Planning. It is recommended that the land and regulatory powers currently held by Sydney Water be transferred to the Catchment Commission, with the Commission being able to utilise staff of existing agencies such as the Environment Protection Authority or the National Parks and Wildlife Service to enforce regulations.

Problems with Laboratory Testing The results of water testing carried out by Australian Water Technologies (the Sydney Water Corporation laboratory), and by other laboratories in Australia, the UK and the US are summarised. From the evaluation of the test results from all sources, the Inquiry concluded that there is strong evidence that numbers of *Cryptosporidium* oocysts present during the First Event (late July /early August) were overestimated by AWT.

Algal cells of similar appearance to protozoa were also present in samples and these may sometimes have been mis-identified as protozoa. Many of the organisms present during the First Event appeared to be degraded and were unlikely to be capable of causing infection. As AWT did not routinely confirm the presence of intact protozoa by DAPI staining, the degraded organisms may have led to overestimation of numbers.

Nevertheless, the Inquiry concluded that based in examination of slides from the First Event by a number of experts *"that definitive oocysts and cysts were present in drinking waters at levels of possible public health concern"*. The actual levels of definitive protozoa are not stated. For the Second Event (late August) it was also concluded that *Cryptosporidium* and *Giardia* were present but again the reported levels were often overestimated. Samples taken during the Third Event (early September) were found to be most unreliable and in many cases it appears other cells were wrongly identified.

The report also describes the results of audits conducted at AWT and Macquarie University laboratories which noted significant shortcomings in quality control systems. It was concluded that the

massively increased workload at AWT as the crisis continued led to a breakdown of already poor quality control procedures. This meant that the water testing data was not sufficiently reliable to meaningfully assess the performance of water treatment plants in removing protozoa during the contamination events.

The Inquiry has recommended that an adequately resourced independent laboratory be established without delay in order to provide accurate data for regulatory authorities.

Operation of Water Treatment Plants The report summarises the characteristics of the 11 water treatment plants serving Sydney, and their performance in terms of turbidity fluctuations during the contamination events. The results of protozoa tests are also listed although note is made of their doubtful reliability, especially in relation to the Third Event.

For the Prospect plant, the Inquiry concluded that the planned maintenance procedures being carried out in July resulted in several operational deviations that may have allowed passage of protozoa through the plant at higher levels than usual. Increased levels of organisms may have also been present in the raw water at some times during this period.

During this time water demand was low (winter season) and the plant was being operated to achieve economy while remaining within specifications (ie long filter runs, low coagulant doses, recycling of treated backwash water). The Inquiry concluded that the very high readings reported in the distribution system as the First Event progressed were most likely to have arisen from dislodgement of protozoa in biofilm or sediment in the system due to the flushing program, rather than release from within the plant.

Following the First Event, operationing conditions at the Prospect plant were changed to produce maximal turbidity reduction with the result that finished water turbidity was maintained at 0.02 NTU throughout the period when the Second and Third Events occurred.

Backwash water was not being recycled, coagulant doses had been increased and shorter filter runs were used.

The Inquiry concluded that significant numbers of protozoa were present in raw water during these events, although the numbers may have been overestimated. However, because of the problems in reliability of laboratory test results, the numbers passing through the plant are uncertain and no assessment can be made of the plant's efficiency in removing *Cryptosporidium* and *Giardia*.

In order to better assess the capability of the Prospect plant to remove protozoa under a range of raw water conditions, a series of seeding experiments are being carried out on a small prototype plant. The results of these tests will be presented in a later report of the Inquiry.

Of the remaining 10 water treatment plants supplying Sydney, 6 appeared to have performed well during the events although they were not receiving such poor quality water as other plants. Performance problems occurred at Warragamba and Orchard Hills (both receiving highly contaminated raw water like Prospect) and to a lesser extent at the Macarthur plant. Sydney Water has introduced operational measures to correct these problems, and is assessing the need for equipment modifications.

Source of protozoa A number of investigations have been carried out in an attempt to determine whether protozoa in the water during the events originated from human or animal sources.

Analysis of water samples for faecal sterols showed the majority of the contamination was from herbivores, however definite evidence of human faecal contamination was also found in 4 of the 42 samples tested.

Infectivity tests Protozoa concentrates were sent to a US laboratory for infection tests in mice. Due to the limited quantities of *Cryptosporidium* oocysts in the samples, only 8 mice could be inoculated with 250 to 500 oocysts each. None of the animals inoculated from these samples became infected, while mice inoculated with control oocyst samples from calf

faeces showed the expected rates of infection (about 50% of animals infected with a dose of 150 oocysts). Given that the faecal sterol results above suggest the oocysts in Sydney's water came mainly from herbivores (which should readily infect mice), these limited results support the view that the oocysts were either not alive or not infective.

Health impacts of the events The results of investigations by the NSW Health department are summarised, including telephone surveys and enhanced surveillance of laboratories, hospitals, pharmacies, nursing homes and general practitioners. On balance, no consistent evidence of a general increase in diarrhoeal illness was found, nor was there a significant increase in laboratory diagnosed cases of cryptosporidiosis.

As the current surveillance system was able to detect a swimming pool related outbreak of cryptosporidiosis in NSW early in 1998, it appears that no significant increase in cases has occurred as a result of the recent events. A small increase in laboratory diagnosis of *Giardiasis* was seen but this was attributed to greatly increased submission of faecal specimens for testing in response to publicity about the contamination, and changed laboratory testing practices (prior to the incidents only a minority of specimens were tested for protozoa).

The Inquiry concluded "it is most unlikely that any person suffered illness because of ingesting *Cryptosporidium* and *Giardia* in any of the events".

*Updates on the Sydney Water Inquiry can be found on the CRCWQT Web page.*



## New research on aluminium

The Water Services Association of Australia recently published two new reports from its research program on aluminium.

*Aluminium in the Food and Water Supply: An Australian Perspective*<sup>(1)</sup>, assesses the average intake of aluminium for adults and children. Calculation of the average intake of aluminium from food and water

showed that water accounted for 1-2% of total dietary aluminium intake.

The authors compiled Australian and international data on the aluminium content of a wide range of foods, and combined this with information from the 1995 National Nutrition Survey (NNS) to derive estimates of daily intake. Measurements of aluminium content were undertaken for a number of items where existing data was not available, or was considered unrepresentative for Australian foodstuffs. Information on aluminium content of drinking water was obtained from major water authorities, and water intake was based on NNS data.

Average aluminium intakes were found to be higher in males than females, and generally to increase with age. For all age groups except infants, the food items contributing the most to aluminium intake were non-alcoholic beverages and cereal-based products and dishes. For infants, soy-based formula was found to make the highest contribution to aluminium intake. Information from 8 water authorities showed that the average aluminium content in source water ranged from 40 to 838 micrograms /litre, while for water supplied to customers the average levels ranged from less than 20 to 116 micrograms /litre.

The proportion of aluminium derived from water was higher in adults than in children, mainly due to higher consumption of tea and coffee. Average intakes were converted to weekly intake per kilogram body weight in order to compare them to the Food and Agriculture Organisation / World Health Organisation provisional figure for tolerable weekly aluminium intake. Australian average weekly aluminium intakes were found to range from 0.5 mg / kg body weight in adults to 1.4 mg / kg body weight in children. These figures are well below the FAO/WHO provisional tolerable weekly intake of 7 mg / kg body weight.

The authors also discuss other potential sources of aluminium intake including cooking utensils and packaging, beverage containers, coffee percolators, pharmaceuticals, and toothpastes. Of all of these sources, only some pharmaceuticals (aluminium containing antacids) were considered

likely to contribute significantly to aluminium intake.

***Bioavailability of Aluminium in Alum-Treated Drinking Water and Food***<sup>(2)</sup>, describes the results of a study undertaken in volunteers to determine whether differences exist in the absorption of aluminium from different sources. From these experiments it was estimated that consumption of 1.6 litres of alum treated water per day would contribute only 0.4 to 1.1% of the lifetime body burden of aluminium.

Aluminium is a neurotoxin, however considerable controversy still exists over its possible role in the development of Alzheimers Disease. It is often speculated that aluminium in drinking water may be more bioavailable than aluminium in food, and therefore may contribute disproportionately to aluminium load in the body.

In this study, 29 volunteers aged from 35 to 76 years participated in a series of experiments where they consumed a controlled diet with either reconstituted soft water (RSW) or alum treated water (ATW) from a major urban supply. The aluminium content of RSW was less than 1 microgram /litre, while that of the ATW was 130-147 microgram /litre. This study differed from others as the water consumed by the volunteers was not deliberately spiked with aluminium, and food intake was strictly controlled.

Each experiment lasted two days - on the first day the volunteers consumed the standard diet with RSW, and on the second day they consumed the standard diet with either RSW or ATW. In half the experiments citrate was added to both types of water on the second day. Citrate is believed to act as a chelating agent for aluminium and may increase the solubility and bioavailability of aluminium in the digestive tract.

The standard diet was a homogenised meal for lunch and dinner consisting of beef, potatoes, broccoli, carrot, wholemeal pasta, wholemeal bread, pasta sauce, cheese, mixed herbs and salt. For breakfast a commercial cereal was supplied with milk, and snacks of biscuits, bananas and instant tea were allowed during the day. The aluminium content of

representative samples of all foodstuffs was analysed, and volunteers returned unused food for weighing. Daily aluminium intake during the experiments was around 3.2 milligrams - somewhat lower than the average adult intake of 4.9 to 6.5 milligrams.

Each volunteer took part in 4 experiments in a factorial crossover design - with RSW +/- citrate and with ATW +/- citrate. Volunteers collected 24 hr urine specimens taking precautions to avoid contamination with dust, clothing fibres etc, and blood samples were collected in a "clean room". All volunteers were non-smokers, and the use of aluminium containing deodorants and medications was not permitted for one month prior to and during the experiments. Alcohol and coffee were not permitted during the experiments. Aluminium in plasma and urine samples was determined using axial inductively coupled plasma atomic emission spectrometry (ICPAES).

It was found that plasma aluminium levels did not rise significantly 2 hours after ingestion of alum treated water, but mean daily excretion in urine rose by 9%. The estimated bioavailability of aluminium from food was in the range of 0.28 to 0.64% depending on the assumed value for aluminium from tea. The bioavailability if aluminium from alum treated water was calculated to be 0.37% of total aluminium or 0.56% of the chemically labile fraction. The observations support the conclusion that the bioavailability of aluminium in alum treated water is similar to that of aluminium in food and beverages. Therefore aluminium in drinking water is unlikely to make a major contribution to aluminium body burden as it represents only 1 to 2% of total daily aluminium intake.

1) Aluminium in the Food and Water Supply: An Australian Perspective. JL Allen and FJ Cumming. UWRAA Research Report No. 202, November 1998.

2) Bioavailability of Aluminium in Alum-Treated Drinking Water and Food. JL Stauber, CM Davies, MS Adams and SJ Buchanan. UWRAA Research Report No. 203, November 1998.

WSAA contact details: Fax + 61 3 9606 0376

## Early detection can reduce impact of outbreaks

Analysis of the Milwaukee cryptosporidiosis outbreak has demonstrated that up to 85% of cases of illness could have been prevented had surveillance systems been able to detect the outbreak earlier.

Researchers at the University of California applied an epidemiologically based mathematical model to the observational data from Milwaukee to examine the factors that contributed to the outbreak. The model was used to test which combinations of factors would predict an epidemic curve similar to the real outbreak. The factors analysed included:

- clinical properties
  - dose-response
  - incubation period
  - duration of immunity
  - duration of symptoms
  - % of infected people with symptoms
- surveillance data
  - nonoutbreak incidence
  - oocyst levels in surface waters
- plant treatment efficiency

For each factor a range was defined based on observations from the Milwaukee outbreak, and information from other studies. Where no information was available, a wide range was used to allow for uncertainty. Five criteria were set for the simulation to be acceptable:

### 1 Background disease rates (prior to outbreak)

- The percentage of cases due to drinking water is between 0 and 25%
- The monthly incidence before March was between 0.08 and 1.67 cases /100,000 population.

### 2 Outbreak magnitude

- Number of cases during March and April must be between 300,000 and 500,000.

### Outbreak Timing

- Incidence for 23-29 March must be less than half the incidence for 30 March - 4 April

- Incidence for 12-18 April must be less than 5-11 April.

One million computer simulations covering the period from 2 March to 2 May were run with only 800 able to pass the criteria. Comparison of the estimated number of cases per week in these 800 simulations with the observational data from Milwaukee showed that the model consistently underestimated the cases of disease prior to 23 March (when treatment plant failure had been assumed to begin). The number of predicted cases per week in the remaining period were consistent with observational data.

Two possible explanations are suggested for this observation: firstly that the endemic level of watery diarrhoea in Milwaukee residents was actually 10-fold higher than the assumed value of 0.5% per month, or secondly that an unrecognised outbreak with a 10-fold increase in rates of watery diarrhoea was already occurring before the main outbreak. The endemic level of diarrhoea was estimated from a telephone survey undertaken after the outbreak, and is thought to be reasonably accurate. Therefore the second explanation appears to be most likely.

The authors comment that about 15% of the 400,000 cases occurred in the early period, and that if a more sensitive surveillance system had been in operation the major outbreak may have been avoided.

The model simulations suggest that the major outbreak was due to a concurrent 3-fold increase in oocyst concentration in raw water and a 3-log decrease in treatment efficiency. This assumes that the plant normally removed between 3 and 6 logs of oocysts and that even when the plant failed, at least 1 log removal was still occurring. Models of this nature can help to decrease the uncertainties in risk assessment and elucidate some aspects of the disease process.

An analysis of the Milwaukee cryptosporidiosis outbreak based on a dynamic model of the infection process. JE Eisenberg, EYW Seto, JM Colford Jr, A Olivieri and RC Spear. (1998) *Epidemiology* **9** p255-263.

## Conference Reports

### 4th International Conference on Toxic Cyanobacteria

Beaufort, North Carolina, 27 Sept - 1 Oct 1998.

By Andrew Humpage, Department of Pharmacology, University of Adelaide / CRCWQT.

The 4<sup>th</sup> International Conference on Toxic Cyanobacteria was held at the Duke University Marine Laboratories in Beaufort, North Carolina, from 27<sup>th</sup> September to 1<sup>st</sup> October this year. This conference followed on from the very successful 1<sup>st</sup> ICTC held on the Baltic island of B rnholm in 1995 (the apparent lack of 2<sup>nd</sup> and 3<sup>rd</sup> ICTC's is complicated to explain and not germane). Attendance was limited to about 150 registrants so as to maximise the opportunity for people to make oral presentations as well as to discuss their experiences informally.

Australia was well represented, with 16 people making the trip. Eight of these were from the CRC for Water Quality and Treatment, including three people from the University of Adelaide laboratory:

- Ian Falconer gave a Plenary Lecture entitled "Health risks from cyanobacterial toxins in drinking and recreational water".
- Andrew Humpage gave an oral presentation entitled "Flow cytometric analysis of microcystin-LR-induced effects in proliferating hepatocytes in culture". (I also visited the laboratory of Prof. Geoffrey Codd at the University of Dundee after the conference.)
- Suzanne Froschio presented a poster entitled "Toxicity of an aqueous *Cylindrospermopsis raciborskii* extract and HPLC purified cylindrospermopsin towards primary hepatocytes in culture".

Three people from the Australian Water Quality Centre gave oral presentations:

- Joanna Rositano, "A method for the extraction and analysis of PSP's from drinking water".
- Mike Burch, "Ecology and management of toxic cyanobacteria in the Murray River, South Australia –

A scummy life in a lazy river, where speed kills and starvation is a threat"

- Peter Baker, "Life history and ecology of the toxic cyanobacterium *Anabaena circinalis* in the lower Murray River, South Australia".

And two from the University of New South Wales:

- Brett Neilan, "Toxins and taxonomy: the distribution and detection of pathogenic cyanobacteria".
- Daniel Tillet, "Structural analysis of the *Microcystis* genome associated with microcystin biosynthesis" (poster).

The National Research Centre for Environmental Toxicology (NRCET) was ably represented by:

- Glen Shaw, "Cylindrospermopsin production by two cyanobacterial species in Australia".
- Alan Seawright, "Effect of hepatic xenobiotic metabolism on the toxicity of cylindrospermopsin".
- Robyn Chiswell, "Degradation of the cyanotoxin, cylindrospermopsin" (poster).
- Ross Norris, "Choice of standard material and robustness of HPLC-MS/MS assay for cylindrospermopsin" (poster).
- Maree Smith, "The cyanotoxin cylindrospermopsin, produced by *Aphanizomenon ovalisporum* in Australia" (poster).

And Australians from other institutions included:

- Gary Jones, CSIRO Land and Water Sciences Centre, "The plethora of environmental effects on microcystin production: Cell division provides the unifying explanation" (Co-authored with Phil Orr).
- Judith Baker, University of New England, "Bloom and bust: toxin production in cyanobacteria" (poster).
- Ben Long, Latrobe University, "Studies on microcystin production in *Microcystis aeruginosa*" (poster).

Susan Blackburn (CSIRO Division of Marine Research) and Chris Bolch (University of Tasmania)

• sent posters but couldn't attend. Sue's posters was entitled "Akinetes: What do they really do? Studies on *Anabaena circinalis* from Australian waters", and Chris's was "*Nodularia spumigena*: a global clone or a genetic hierarchy?"

As with the previous Børnholm meeting, this conference was highly stimulating due to the enthusiasm engendered by the high quality of the presentations and subsequent discussion. A broad range of topics were covered, with sessions being organised under the following headings:

- Chemistry, detection, new toxins
- Cyanotoxin regulation, production, degradation - new approaches to taxonomy of toxigenic cyanobacteria
- Ecology - toxic waterbloom formation, biotic interactions
- Toxicology/health/economic consequences of toxic cyanobacteria
- Cyanotoxin risk factors, occurrence and management of toxic waterblooms

This breadth, presented in sequential rather than concurrent sessions, is particularly valuable for maintaining the relevance and inter-relatedness of research done, and also for introducing the field to new entrants in one "crash course".

Enhancing the value of this "holistic" approach was the stature of the invited and plenary speakers. These included such "big names" as:

- Prof. Jiri Komarek, University of South Bohemia, "Taxonomy of toxic cyanobacteria"
- Prof. Richard E. Moore, University of Hawaii, "Bioactive compounds from cyanobacteria"
- Prof. Brian Whitton, University of Durham, "Ecology of planktonic cyanobacteria"
- Prof. Maria Runnegar, University of Southern California, "Toxicity and protein phosphatase inhibition"
- Prof. Hans Paerl, University of North Carolina-Chapel Hill, "Environmental effects on harmful cyanobacterial bloom expansion: What are the manageable options?"

- Prof. Wayne Carmichael, Wright State University, "Microcystin concentrations in human livers, estimation of lethal dose - lessons from Caruaru, Brazil"

Prof. Ian Falconer's talk, describing the background and derivation of the guideline safety level for microcystin-LR in drinking water (which was recently formulated by a WHO-convened expert committee, of which Ian was a member) showed nicely the links between basic toxicological research, the greater public health picture, and the regulatory framework within which water providers operate.

A number of topics of emerging interest were highlighted at the conference. These include:

- The isolation and identification of other bioactive compounds from cyanobacteria which may be of use in the future as therapeutic agents or research tools.
- The continuing elucidation of the genetic control of toxin production, allowing the possibility of rapid and sensitive detection of toxigenic species, and, perhaps, the control of toxin production in these species. This work was strongly represented by Brett Neilan's and Daniel Tillet's presentations.
- Further evidence of direct effects on the genome caused by the most commonly detected cyanobacterial toxin, microcystin.
- The ever-increasing diversity and distribution of known toxigenic species. For example, *Cylindrospermopsis raciborskii*, which in Australia produces the toxin cylindrospermopsin, has been found to produce neurotoxins in Brazil. Meanwhile, cylindrospermopsin is produced in Israel by an *Aphanizomenon* species and this cylindrospermopsin-producing *Aphanizomenon* species has also been isolated in Australia by the NRCET people in Brisbane.

Thus, the field is still rapidly expanding, with both the threats posed by, and uses of, cyanobacterial secondary metabolites continuing to be very actively researched world-wide, and in an increasingly multidisciplinary fashion. For example, three large-scale multinational research

programs are being set up in Europe, entitled BASIC, DOMTOX, and CYANOTOX, to focus on different aspects of the problem.

The commitment of Australian researchers to the conference and the field in general was shown by the attendance of 16 people from this country, and by the decision to hold the next ICTC in Brisbane in 2001. The Börnholm and Beaufort meetings were both of great professional and social value to all concerned, so best wishes to Gary Jones and Glen Shaw in matching the high standard that has been set.

Contact details for the Australian authors named above can be obtained from Andrew Humpage ([ahumpage@medicine.adelaide.edu.au](mailto:ahumpage@medicine.adelaide.edu.au)).



### ***Cryptosporidium* in Water: a consensus conference**

Melbourne, 5-6 October 1998.

By Martha Sinclair, Dept. of Epidemiology and Preventive Medicine, Monash University / CRCWQT.

The CRCWQT was one of the sponsors of the *Cryptosporidium in Water* conference held in Melbourne during October. The conference was convened to provide the Australian water industry and public health professionals with an overview of current scientific knowledge, and an opportunity to discuss and debate the needs for future research, public health strategy, and risk assessment and management for water supplies.

The Water Services Association of Australia and the Australian Water and Wastewater Association co-sponsored the conference, and the Department of Human Services Victoria provided sponsorship for one of the international keynote speakers.

The conference was attended by more than 280 delegates from diverse backgrounds in water supply and management, environmental health, parasitology, general microbiology, epidemiology and public health. There is no doubt that interest in the topic was boosted by recent happenings in Sydney, although planning for the conference began several months before this.

The conference was officially opened by Professor Richard Larkins, Chair of the National Health and Medical Research Council who noted the increasing importance of the public health aspects of the environment, and the potential impact of environmental changes on public water supplies.

The conference was organised in three themes, each with its own objectives:

#### Parasitology and Genetic Typing

Introduce genetic typing to assist in locating the source of the parasite.

#### Epidemiology

Improve epidemiological surveillance, outbreak management and public health response.

#### Risk Assessment

Understand the health risks implied by *Cryptosporidium* monitoring results.

The first day was open to all delegates, and on the second day smaller groups of invited participants continued discussions on the three themes with the aim of reaching consensus positions on research needs, public health strategy and risk management principles. Summaries of the three themes are being edited for publication as conference proceedings, and adapted versions will also be submitted for publication in relevant industry and scientific journals.

The overall outcomes of the three specialist workshops can be summarised as follows:

#### **Parasitology and Genetic Typing**

Research on *Cryptosporidium* has been hampered by the lack of sufficient supplies of oocysts from well characterised isolates to allow parallel testing by different laboratories. It was agreed that establishment of oocyst banks with a diverse range of well documented isolates and propagation of selected isolates by animal culture would greatly facilitate comparative work. Cooperation is also needed to optimise standard methods for purification and storage of oocysts, and for extraction of nucleic acids and proteins.

Availability of this standardised material will then allow the application of a range of molecular and

biochemical techniques to identify markers that can distinguish between individual isolates. Once such markers are defined they will permit us to trace the origins of individual strains, and some may ultimately provide an indicator for human infectivity.

### **Epidemiology**

Public health and epidemiology experts agreed that the development of a typing system to distinguish individual strains would provide greater understanding of the relative importance of different sources and routes of disease transmission within the community. National cooperation is needed to improve and standardise surveillance methods, and to provide advice and information to the medical profession and laboratory services. Community education was seen as an important part of the public health strategy, and this is particularly crucial for the management of swimming pool related outbreaks where engineering and operational changes can only reduce but not eliminate risks.

On the issue of water monitoring there was agreement that rational public health responses could not presently be based on the results of tests for *Cryptosporidium* in finished water. It was felt that careful monitoring turbidity and investigation of turbidity events provided a better approach, and that water utilities and health authorities should jointly develop response protocols which were subject to public consultation.

### **Risk Assessment**

This stream of the conference considered both the specific issues of the interpretation of monitoring results and the broader context of risk management for the water industry. It was agreed that the management of *Cryptosporidium* should be based on a quality management approach tailored to the characteristics of each water supply. This strategy would reduce the risks for a range of microbial pathogens by the application of best management practices throughout the water supply system. A number of existing quality management and risk assessment systems were seen as providing potentially useful models - including ISO 14000 for environmental management, AS/NZS 4360:1995 and Hazard Analysis and Critical Control Points (HACCP).

It was agreed that routine monitoring of finished water supplies for *Cryptosporidium* was impractical and unlikely to be statistically meaningful, but there was mixed opinion on whether some monitoring might be seen as necessary to demonstrate due diligence towards consumers. All agreed that there is a need for industry and regulators to work together in developing appropriate risk-based monitoring strategies for protection of consumer health and due diligence purposes.

In summary, the conference provided an excellent update on the "state of the art" in *Cryptosporidium* research, and an opportunity for productive discussions and networking between Australian and international delegates. It is clear that both public health and water industry professionals share many concerns over the difficulties in dealing with *Cryptosporidium* in water supplies given the limitations of our current knowledge and methodologies.

There was general agreement that a cooperative and considered approach to the problem was the best way to ensure cost-effective protection of public health. A number of initiatives in research, public health and water management have originated from the conference, and will be developed by the CRCWQT in conjunction with other water industry bodies and health authorities.



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### **News Items**

### **CRCWQT / WSAA reference group formed**

Following a workshop in Adelaide on 18<sup>th</sup> and 19<sup>th</sup> of November, the CRCWQT and WSAA have formed a joint reference group to develop a proposal for a formal water quality management framework for the Australian water industry.

It is envisaged that the framework will enable the adoption of a holistic approach to water quality management by critically evaluating individual systems and their specific hazards, and developing strategies to control, reduce or eliminate the hazards at multiple points throughout the system (catchment to tap). This will provide a preventive approach to public health protection by ensuring that every step in water production is protected by a series of safeguards, and that variations from normal conditions are detected in a timely manner which allows an appropriate response before the problem impacts on the consumer.



### **UK *Cryptosporidium* outbreaks mainly due to human sources?**

Molecular typing of *Cryptosporidium parvum* isolates from two waterborne outbreaks in the UK has shown that the majority of isolates were of the Type 1 genotype which is believed to be transmitted only between humans.

Researchers tested 95 human isolates from 2 waterborne outbreaks, 46 from sporadic human cases, and 62 from livestock. 96% of the outbreak isolates were of Type 1, 59% of sporadic isolates were Type 1 and 35% were Type 2, and 100% of livestock isolates were Type 2. These results indicate that human sewage contamination was the primary cause of the two waterborne outbreaks. (Patel et al. (1998). *Commun Dis Public Health* 1 (4) p231-233).



### **Fluoridation targeted in British health strategy**

A scientific advisory group has recommended legislative changes to make water fluoridation easier, as part of a package of measures to improve the

health of poor and disadvantaged groups in Britain. The British Medical Association has endorsed the recommendations of the advisory group to allocate more resources to reduce health inequalities.



### **Geological origin for nitrate**

Researchers from the University of California have presented evidence that much of the nitrate in water may originate from geological sources not human activities. In a letter to the 22 October issue of *Nature*, they describe a 30 month study of a watershed with mixed types of bedrock. Measurements of nitrogen flux and calculation of mass balance showed that 10% of the catchment area with nitrogen rich bedrock contributed 90% of the nitrates to river water.

The authors suggest that geological nitrogen may be a significant and unrecognised source of nitrates in surface waters. (Holloway et al. (1998) *Nature* 395 p785-788).



### **Global warming - worse floods predicted**

A multinational scientific team has reported that rises in sea levels during the last century may have been primarily due to thermal expansion of the oceans rather than melting of the polar icecaps. Using satellite signals to accurately measure the thickness of the Antarctic icecap, the team found that melting ice could account for less than 2cm of the 18cm rise on sea levels over the last 100 years.

If confirmed, these findings suggest that thermal expansion will have a much larger effect than previously estimated, and sea levels may rise even more than predicted.



### **UK to proceed with Crypto legislation**

It was announced on 2 November that the British government will proceed with legislation to require continuous water monitoring for *Cryptosporidium* and make it a criminal offence for water treatment

plants to exceed an average of 1 oocyst per 10 litres. According to a press release from the Department of the Environment, Transport and the Regions, the legislation has been broadened to include some ground water supplies, as well as surface water supplies.

**Correction:** The UK legislation was reported in the last issue of Health Stream but an error was made in cost calculations - the cost of preventing a case of cryptosporidiosis should have been £53,000 per case, not £24,000 as reported (p12).



### **More concern but less action on environment**

A survey by the Australian Bureau of Statistics has shown that while many people express concern about the environment, few take active steps to modify their own behaviour in terms of conservation or recycling. Comparison with a survey undertaken in 1992 suggests that fewer people have donated time or money to environment protection, and fewer use recycled paper or phosphate-free cleaning products.



### **Rehabilitation plan for Great Artesian Basin**

The Great Artesian Basin Consultative Council has recommended an \$280 million plan to the Australian Federal government to rehabilitate the basin and protect underground water resources. The basin covers an area of 1.7 million kilometres (almost 20% of Australia) and supplies water up to 2 million years old to some of the driest regions of the continent.

More than 570 million litres of water are extracted from the basin each year and it is estimated that up to half of this may be wasted due to uncapped bores and unlined drainage channels. This has led to pressure drops in some areas which make it increasingly difficult to extract water from depths of 500 metres or more.

Under the plan, \$220 million would be allocated for bore capping and piping, while \$60 million would be channelled into environmental and cultural protection, monitoring and research.

## **From the Literature**

### Disinfection by-products

#### **Effect of water temperature on dermal exposure to chloroform.**

Gordon SM, Wallace LA, Callahan PJ, Kenny DV, Brinkman MC. *Environ Health Perspect* (1998) **106**(6) p 337-345.

This paper describes a new continuous monitoring technique to measure trace volatile organic compounds (VOCs) in air or exhaled breath, and its use to measure the effect of water temperature on dermal exposure to chloroform while bathing in chlorinated domestic tap water.

A full face mask with purified air supply was used and exhaled breath was delivered to a glow discharge source/ion trap mass spectrometer for continuous real-time measurement of chloroform in the breath. Ten subjects were monitored while bathing in chlorinated water and breathing pure air. Of the 10 subjects, 7 bathed in water at various temperatures between 30°C and 40°C. Chloroform levels in the water ranged from 40 to 98 microgram/litre.

Breath measurements indicated that subjects bathing at the highest temperatures (38-41°C) exhaled around 30 times more chloroform than they did at the lowest temperatures (28-32°C), (average of 7.0 microgram compared to 0.2 microgram). A possible explanation for this is the body's response to low temperatures, which is to greatly reduce blood flow to the capillaries closest to the skin surface, resulting in the chloroform having to diffuse over a greater distance to reach the bloodstream. This study shows that dermal absorption is strongly influenced by temperature and therefore existing pharmacokinetic models should use temperature-dependent parameters.



### Cancer

#### **Lung and kidney cancer mortality associated with arsenic in drinking water in Cordoba, Argentina.**

Hopenhaynrich C, Biggs ML, Smith AH. *Internat J Epidemiol* (1998) **27**(4) p 561-569.

Previous studies have found associations between ingestion of arsenic and internal cancers. Most of the studies have been conducted in southwestern Taiwan where drinking water contains high levels of arsenic. This study was undertaken in Cordoba Argentina where exposure to arsenic from drinking water has been previously documented. Prior to this study a dose-response relationship was found by the authors between bladder cancer mortality and arsenic exposure in Cordoba. To extend this analysis further kidney, lung, liver and skin cancers were investigated.

Mortality statistics from Cordoba Department of Vital Statistics for 26 counties for the years 1986-1991 were studied. Exposure was assessed using water measurements gathered in previous studies. Based on available data, counties were grouped into three categories; high, medium and low exposure to arsenic. Standardised mortality ratios (SMR) for kidney, lung, liver and skin cancers for each county were calculated, with males and females analysed separately. All of Argentina was used as the reference population.

Results show a dose-response relationship between arsenic in drinking water and risk of cancers of the kidney and lung, which is consistent with previous studies. The highest SMR was found for lung cancer among men. Liver cancer showed a slight positive trend for men and women but SMR was significantly elevated even in the low exposure group. Skin cancer results were hard to interpret with women having elevated cancer mortality in the high exposure group and men showing an increase in mortality in the low exposure group. This may be due to non-melanoma skin cancers having a low fatality rate and inaccuracies in diagnosis.

In conclusion, a dose-response relationship was found between ingestion of arsenic from drinking water and risk of kidney and lung cancers. There was not a clear association between liver and skin cancers and arsenic exposure. It should be noted that cancer mortality for the period 1986 - 1991 reflects exposures to carcinogens up to the 1970s.

Recognition of the risks posed by arsenic resulted in discontinued use of affected water sources after the 1970s in larger population centres in Argentina, although substantial exposures may still occur in some rural populations.

### **Drinking water mutagenicity and urinary tract cancers - a population-based case-control study in Finland.**

Koivusalo M, Hakulinen T, Vartiainen T, Pukkala E, Jaakkola JJK, Tuomisto J. *Am J Epidemiol* (1998) **148**(7) p 704-712.

When water containing organic material is chlorinated, complex mixtures of compounds are formed, some of which are carcinogenic and/or mutagenic. In Finland high levels of mutagenicity have been detected due to chlorination of surface waters which are rich in humic material.

A case-control study was undertaken to assess the relationship between risk of kidney and bladder cancers and estimated historical exposure to drinking water mutagenicity. A total of 732 bladder cancer cases and 703 kidney cancer cases were obtained from the nationwide Finnish Cancer Registry for the years 1991-1992. Controls were 914 randomly selected individuals from the national population registry and were frequency matched for sex and age group with cases.

A questionnaire was sent to participants to obtain information on previous water sources, addresses and possible confounders such as smoking. Information was gathered from the municipal waterworks on water-pipe connections and past drinking water quality and treatment practices.

Historical exposure to mutagenic drinking water was estimated for each person using the information from the water works and information from the questionnaire on past water sources and residence. Mutagenicity was expressed in terms of revertants /litre of water using the Ames *Salmonella typhimurium* test. This value was derived from an equation based on water quality parameters and treatment practices.

Odds ratios were estimated for a 3,000 net revertant /litre increase in average exposure to mutagenicity for all participants and those with 30 years or more of estimable exposure from 1950-1987. Adjustment for age, sex, socioeconomic and smoking status was made.

The results showed a small statistically significant exposure-related excess risk for kidney cancer in men (odds ratio = 1.49, 95 % confidence interval (CI) 1.05-2.13) for the 3,000 net rev/litre exposure level. For women no significant association was found for kidney cancer with an odds ratio of 1.08 (95% CI 0.69-1.68). A nonsignificant result for bladder cancer for both men and women with odds ratio of 1.22 (95% CI 0.92-1.62) for 3,000 net rev/litre exposure was found. For male nonsmokers there was a higher odds ratio of 2.59 (95% CI 1.13-5.94) for 3,000 net rev/litre exposure.

The authors note a number of possible sources of bias which may have influenced the results including lack of response or incomplete data (30 year exposure data was complete for only 57% of people), possible use of alternative water sources (eg private wells), and differential response by different socioeconomic groups. Another potential source of bias is the use of proxy respondents for 29% of case interviews (ie relatives of deceased cases), but not for controls.

#### **Tetrachloroethylene-contaminated drinking water and the risk of breast cancer.**

Aschengrau A, Paulu C, Ozonoff D. *Environ Health Perspect* (1998) **106**(Suppl 4) p 947-953.

In 1980 the Massachusetts Department of Environment Protection discovered that water distribution pipes in the upper Cape Cod area were leaching tetrachloroethylene (PCE) from their inner vinyl lining. Several years later the Massachusetts Department of Public Health reported an increased incidence of cancer deaths in the upper Cape Cod area from 1969 to 1983.

A population based case-control study was undertaken to examine the relationship between several types of cancer and air and water pollution

including PCE. This paper reports on one aspect of this study relating to breast cancer.

The study population consisted of 258 breast cancer cases diagnosed from 1983 through 1986 among permanent residents of five towns in the upper Cape Cod area and 686 demographically similar controls who were permanent residents living in the same area from 1983 to 1986. Exposure to PCE-contaminated water was calculated using an algorithm that accounted for residential history, water flow, and pipe characteristics. The authors note this method gives only a relative estimate of potential exposure, and cannot be related to actual PCE levels (for which no historical measurements are available). Analysis was conducted considering both no latency and several latency periods as PCE may act as a tumour initiator or as a growth promoter for existing cancers.

Among women who were ever exposed to PCE no significant increase in breast cancer risk was seen when latency of 0 to 15 years was considered. When only highly exposed women were considered no increase or small increases in risk were seen when latency of 0 or 5 years was used. However if 7 or 9 years of latency were assumed, women with high relative delivered doses had increased risk of breast cancer. However, this result should be interpreted with caution because the increased risk was only found in the 7 and 9 years latency period and the proportion of exposed subjects was small (6 or fewer subjects in each exposure class). Greater than 9 years latency was not able to be analysed because of the insufficient numbers.

Overall, a small proportion of exposed subjects means it is difficult to draw conclusions from these results, and there are a number of possible sources of error including lack of water consumption data, and lack of information on occupational exposures. The authors note that studies in highly exposed occupational groups (eg dry cleaning workers) have failed to show increased risks of breast cancer in female workers.



Cryptosporidium**Waterborne outbreaks of cryptosporidiosis.**

Craun GF, Hubbs SA, Frost F, Calderon RL, Via SH. JAWWA (1998) 90(9) p 81-91.

Waterborne disease outbreaks, although greatly reduced since early this century, still occur even when water systems meet recognised quality parameters. This paper reviews the epidemiology and causes of 35 waterborne outbreaks of cryptosporidiosis which occurred in the United States, United Kingdom and Canada from 1984 to 1996.

Outbreaks occurred with groundwater systems and with both filtered and unfiltered surface water supplies. For most of the outbreaks a plausible cause was identified such as deficiencies in water treatment processes or unusual events which increased the contamination of the water source. Contamination of water distribution systems was also responsible for some outbreaks.

Examination of the available data on oocyst concentrations showed no clear association between the concentration detected in drinking water and the risk of illness or outbreaks, and it is noted that analytical methods for *Cryptosporidium* seem to be relatively insensitive. When assessing the risk of waterborne cryptosporidiosis the role of protective immunity must also be considered. Some studies have suggested that immunity may be acquired through low level sporadic exposure to *Cryptosporidium parvum* in drinking water.

Protection of the source water quality, proper water treatment, good operation and monitoring of treatment plant performance and an effective disease surveillance system are all crucial to prevent waterborne outbreaks. Analytical studies rather than ecological studies need to be performed to adequately assess the risks of endemic waterborne cryptosporidiosis.

The authors conclude that the available knowledge does not support recommendation of an action level for *Cryptosporidium* oocysts in drinking water.

**Seasonality and factors associated with cryptosporidiosis among individuals with HIV infection.**

Sorvillo F, Beall G, Turner PA, Beer VL, Kovacs AA, Kraus P, Masters D, Kerndt PR. Epidemiol Infect (1998) 121(1) p 197-204.

A cohort study of HIV-infected patients aged 13 years and older was undertaken to assess seasonal occurrence and factors associated with cryptosporidiosis in order to gain more insight into the epidemiology of cryptosporidiosis and HIV. A total of 4247 HIV patients from four outpatient clinics in Los Angeles County were enrolled in the study and their medical records were followed from June 1990 to May 1996. Cryptosporidiosis was diagnosed in 120 patients during this interval, representing a crude rate of 1.5/100 person-years. Cryptosporidiosis occurred in 69 of the 1296 individuals where complete follow-up data until death was available.

The rate of cryptosporidiosis was nearly three times greater in men than women, and blacks had the lowest rate of cryptosporidiosis amongst the racial/ethnic groups. Younger age and low CD4+ lymphocyte count were strongly associated with risk of cryptosporidiosis. The highest rate of cryptosporidiosis was found in the 13-34 year age group and in those with CD4+ counts  $< 100 \times 10^6$  /litre. In seasonal terms, the highest rates of cryptosporidiosis occurred during March, April and May, and during September and October, however the seasonal variation was not dramatic.

It has been postulated that the risk of waterborne cryptosporidiosis may increase following periods of heavy rain, due to contamination of open reservoirs. However, comparison of the monthly rates of cryptosporidiosis with mean monthly rainfall showed no correlation.

**First reported outbreak in the United States of cryptosporidiosis associated with a recreational lake.**

Kramer MH, Sorhage FE, Goldstein ST, Dalley E, Wahlquist SP and Herwaldt BL (1998) Clin Infect Dis 26 p27-33.

This paper describes the investigation of a large cryptosporidiosis outbreak at a recreational lake in a New Jersey state park. It was estimated that 2,070 of approximately 6648 people who visited the park between 15 July and 12 August 1994 developed illness.

Cases of illness associated with the park came to the attention of authorities on 9 August and *Cryptosporidium* oocysts were found in all 3 stool specimens which were the first batch tested. Several hundred people who had visited the park subsequently contacted the health department in response to a publicity campaign. 185 people who had visited the park only once were interviewed to determine their food and water consumption, contact with lake water, gastrointestinal symptoms and other possible exposures (eg looking after young children). Stool specimens were requested from both well and ill participants.

From the 185 visitors, 38 cases were identified (4 by stool analysis, 34 by clinical symptoms) giving an attack rate of 20.5%. A higher attack rate was seen in 18 people who had visited the park more than once (11 of 18 visitors, or 61.1%). Of all the risk factors assessed, only contact with lake water was strongly associated with illness (Relative Risk =11 for any exposure vs none).

Attack rates among those with water contact were about 64% for the first 3 weeks of the outbreak period but fell to about 18% by the 4<sup>th</sup> week (just before the lake was closed on 12 August). Attack rates were highest in those who immersed their face or took water into their mouths, and in those with longer contact times.

The lake occupied an area of 105,000 sq metres and had a marked swimming area of 3,917 sq metres. Average water depth was 1.2 metres. Samples of lake water and drinking water taken on 17 August were negative for *Cryptosporidium* but 2 of 3 lake water samples taken on 21 September were positive (7 and 21 oocysts per litre). The authors comment that these levels are consistent with background levels of contamination from wild animals. High faecal coliform counts were recorded in the swimming area on 10 and 12 August (500 and more

than 1600 respectively per 100 ml).

No leakage of the septic tank system from the public toilets was detected by a fluorescein dye test, but a tank overflow had occurred on 14 July due to a pump failure. The spillage was reportedly confined to an area about 60 metres from the beach however heavy rain next day (46 mm in 6 hours) may have caused runoff of sewage into the lake. Study participants gave anecdotal reports of parents rinsing diapers in the swimming area, children in diapers in the lake, and faecal accidents in the water.

The authors conclude that either the sewage spill or direct contamination by swimmers may have been the initial event, and that continued contamination by swimmers may have prolonged the outbreak. They recommend better public education regarding risks of faecal pollution of recreational waters, and better design of parks to separate swimming areas from potential sources of sewage contamination.



#### Exposure Assessment

#### **Assessment of water use for estimating exposure to tap water contaminants.**

Shimokura GH, Savitz DA, Symanski E. Environ Health Perspect (1998) **106**(2) p 55-59.

Accurate assessment exposure of individuals to tap water is often a main methodological difficulty with epidemiological studies that examine the relationship between exposure to tap water contaminants and disease outcomes such as cancer. This study provides detailed information on tap water consumption, showering and bathing habits of pregnant women and their male partners and examines behaviours that may affect tap water exposure.

Eligible female participants who were up to 30 weeks pregnant were identified by reviewing medical records at an Obstetrics and Gynaecology clinic in a North Carolina hospital. A total of 36 couples were interviewed out of 71 couples approached. Two couples and one male partner did not complete the

required 3-day water consumption diary.

Interview-based questionnaire data was compared with diary records and good agreement was found between them for drinking water consumption and time spent showering and bathing. On average, participants consumed close to the National Academy of Sciences' assumed 2 litres of water/day. Pregnant women and their male partners had similar water intake levels. Women employed part-time or less consumed the most tap water.

Full-time employees had less variation in consumption patterns over time when compared to women working part-time. Ninety percent of participants showered, with women showering on average for 11.6 +/- 4.0 min and men 10.4 +/- 4.8 min. More men showered than women (94% vs 79%) and more women took more baths than men (18% vs 3%). Average duration of baths was 22.9 +/- 10.1 min for women and 21.3 +/- 12.4 min for men.

In conclusion, information from this report can be used for developing exposure assessment methods, and will be useful in the interpretation of epidemiological studies examining health problems which may be associated with tap water.



### Fluoride

#### **The association between water-borne fluoride and bone mineral density in older adults.**

Phipps KR, Orwoll ES, Bevan L. J Dent Res (1998) 77(9) p 1739-1748.

A cross-sectional study was undertaken in order to examine the effect of fluoride on bone mineral density in older adults.

Subjects were drawn from 3 rural communities each with different levels of naturally occurring fluoride in their water supplies (0.03, 0.7, 2.5 mg/L). Eligible participants were aged 60 and over, and had been drinking from the municipal water supply for 20 years or longer. A total of 353 women and 317 men

were recruited and interviewed about the variables known to influence BMD. All participants were white and non-Hispanic. Dual-energy x-ray absorptiometry was used to measure bone mineral density (BMD) in the lumbar spine, proximal femur and forearm for each participant.

The BMD of the lumbar spine was significantly higher in men and women who lived in the community with the highest level of fluoride compared to those from the communities with moderate or low fluoride levels. Proximal femur BMD was significantly higher in women from the high fluoride community. BMD in women was also influenced by other factors including body weight, oestrogen deficiency, current oestrogen use, family history of osteoarthritis, caffeine intake, diuretic use and smoking

No statistically significant difference was found in men for proximal femur or forearm BMDs in the different communities. The authors conclude that exposure to fluoride at higher levels for 20 years or more has a positive effect on lumbar spine and proximal femur BMD. It appears from the results that exposure to fluoride at the "optimal" level to prevent dental caries (0.7 to 1.2 mg/L) has no significant effect on bone mineral density, but higher level exposure may increase BMD.



### Legionella

#### **Legionella in water distribution systems.**

Lin YE, Vidic RD, Stout JE, Yu VL. J AWWA (1998) 90(9) p 112-121.

The bacterium *Legionella* that causes Legionnaires' disease can be detected in low concentrations in lakes and rivers, however it can be most commonly found in biofilms through out water distribution systems. Outbreaks of Legionnaires' disease have been linked to the water systems of hospitals, industrial plants and homes, and hot water distribution systems can provide the bacteria with optimal conditions for growth.

Various methods of disinfection are used for controlling *Legionella*, this paper reviews some of these and reports on the method of use, the advantages, disadvantages and cost of each. Disinfection methods discussed include: Copper-silver ionization, Thermal eradication (superheat and flush procedures), Ultraviolet (UV) light, Hyperchlorination, and Ozone treatment.

A number of measures often recommended by public health authorities for control of *Legionella* have not been scientifically validated and some have been proven ineffective - including good engineering practice and preventive maintenance. Maintenance of water temperatures above 60 C has been shown to be an effective means of eliminating *Legionella*, but this is often neither practical nor desirable in institutional settings.

It is important to routinely culture environmental samples for *Legionella*, this is an inexpensive process and is a rational long term approach to successful disinfection. Shut down of water lines during construction works may be associated with higher risks of *Legionella* colonisation.

Thermal eradication (superheat and flush procedures) can be used as an emergency procedure during an outbreak, while Copper-silver ionization is presently used in more than 30 hospitals in the United States and appears to offer a cost-effective control method.



### Magnesium

#### **Magnesium in drinking water and body magnesium status measured using an oral loading test.**

Rubenowitz E, Axelsson G, Rylander R. Scand J Clin Lab Invest (1998) **58**(5) p 423-428.

A number of epidemiological studies have shown reduced mortality from cardiovascular disease in populations consuming water with high magnesium levels. An investigation was undertaken to determine whether a change in body magnesium status could be measured in people who changed from drinking water with a low magnesium level to water with a higher level.

Participants were from the city of Goteborg, Sweden and were 65-70 years old. They were selected from among control participants in a previous unrelated study, and were chosen on the basis of self reported low vegetable consumption (and were thus likely to have relatively low dietary magnesium levels). A total of 9 men and 3 women took part in the study. Magnesium concentration in tap water is low in Goteborg (about 1.6 mg/l).

Subjects were supplied with magnesium chloride supplemented drinking water (25 mg of magnesium /litre) for 6 weeks, and instructed to use this for drinking and cooking. They were interviewed and administered a questionnaire before and after the supplementation period, and given an oral dose of 575 mg magnesium in tablet form at each interview. Basal excretion of magnesium, potassium and creatinine and excretion after magnesium tablet loading was measured in samples of 24h urine before and after the supplementation period.

Magnesium intake via water increased from  $1.1 \pm 0.8$  before supplementation to  $18.4 \pm 12.6$  mg/day after the 6 weeks of supplementation. Results showed that post-load excretion of magnesium was increased in relation to creatinine after 6 weeks of water supplementation. A mean increase of 14.6% in post-load excretion was found. There were no changes found for potassium excretion.

The authors conclude that the extra magnesium given via the drinking water was sufficient to increase the body magnesium levels over this time period, and that magnesium in water may be more bioavailable than magnesium in food.

#### **Prevalence of diabetes mellitus and hypertension in relation to chemical composition of drinking water - does magnesium protect against diabetes mellitus?**

Mahaba H. Saudi Med J (1998) **19**(4) p 469-474.

This study examined the relationship between the chemical composition of drinking water and the prevalence of diabetes mellitus and hypertension.

A cross-sectional study was undertaken in the Hail region of Saudi Arabia involving primary health care centres (PHCCs). Each PHCC keeps a register of chronic illnesses including diabetes and hypertension. From May 1995 to May 1996 each of the 88 PHCCs in this region were visited and records of chronic cases were examined. From the catchment area of each centre a total of 264 samples from the main sources of drinking ground water were collected. The chemical constituents of these samples were correlated with the prevalence rates of diabetes mellitus and hypertension at the corresponding PHCC.

A total prevalence of 1.77% for diabetes mellitus and 2.1% for hypertension was calculated. There was no statistically significant association found between the studied chemicals and the prevalence of hypertension. There was however a strong negative correlation between levels of magnesium, dissolved salts, alkalinity and chlorides in water and prevalence rates of diabetes mellitus. A number of biochemical and animal studies have suggested that magnesium levels may play a role in diabetes. No correlation was found between calcium content and diabetes mellitus.

The level of magnesium chosen as the cut off value in this study is not particularly high (10 mg /litre) but the authors suggest that in desert regions like Saudi Arabia where green vegetables are not plentiful, water may have greater relative importance as a source of magnesium. This is essentially an ecological study and it should be noted that water sources and intakes for individual patients were not assessed, and magnesium levels are inferred from the area of residence. Several important factors which may influence the rate of diabetes such as obesity and genetic predisposition are not considered, and there is no discussion of any differences in regional mortality rates which may affect the numbers of prevalent cases of any disease.



### Risk Assessment

#### **Total body burden from inhalation during showering with benzene-contaminated drinking water - implications for cancer risk.**

Giardino NJ, Wireman JR. J Hazard Materials (1998) 62(1) p 35-40.

This paper highlights the importance of total body burden (TBB), the amount of contaminant in the body at a given time, when assessing risk, in particular when exposure is a result of inhalation. The United States Environmental Protection Agency (USEPA) assesses risk on the basis of air or water contaminant concentrations and exposure durations without considering TBB. A comparison was made between benzene TBB inhalation cancer risk and ingestion cancer risk, and also between benzene TBB inhalation cancer risk and inhalation cancer risk derived using USEPA methodologies. TTB was calculated using a pharmacokinetic model.

Benzene TBB after inhalation during a 6 min shower was compared to benzene TBB after ingestion of 2 litres of water. A benzene concentration of 5 microgram /litre was used in each case. A ratio of 8 to 1 was found for inhalation risk versus ingestion lifetime risk for cancer. This indicates the importance of the inhalation route of exposure for homes that have showering water contaminated with volatile organic chemicals such as benzene.

The TBB inhalation cancer risk was then compared with the lifetime cancer risk from inhalation exposure using the current USEPA methodologies and ratio of 58 to 1 was found. This indicates that the USEPA cancer risk methodologies may substantially underestimate the inhalation cancer risk.

This study shows the importance of considering TBB when calculating risk from inhalation. The linear model in this paper can be adjusted to consider any inlet water concentration of benzene or any shower duration, making TBB easily quantified when calculating lifetime cancer risks.



## List of Articles

### Aeromonas

**Characterisation of potential virulence markers in aeromonas caviae isolated from polluted and unpolluted aquatic environments in Morocco.**

Imzilin B, Krovacek K, Baloda SB, Kuhn I, Gonzalezrey C, Svenson SB. FEMS Microbiol Ecol (1998) **27**(2) p 153-161.

### Algae

**Green algae in water supplies - a review.**

Sladeckova A. Biologia (1998) **53**(4) p 557-565.

### Arsenic

**Design of an epidemiologic study of drinking water arsenic exposure and skin and bladder cancer risk in a US population.**

Karagas MR, Tosteson TD, Blum J, Morris JS, Baron JA, Klaue B. Environ Health Perspect (1998) **106** (Suppl 4) p 1047-1050.

### Cryptosporidium

**UV light inactivation of *Cryptosporidium* oocysts.**

Clancy JL, Hargy TM, Marshall MM, Dyksen JE. J AWWA (1998) **90**(9) p 92-102.

**Public reliance on risk communication channels in the wake of a *Cryptosporidium* outbreak.**

Griffin RJ, Dunwoody S, Zabala F. Risk Anal (1998) **18**(4) p 367-375.

**Comparison of ELISA and Western blot assays for detection of *Cryptosporidium* antibody.**

Frost FJ, De La Cruz AA, Moss DM, Curry M and Calderon RL (1998) Epidemiology and Infection **121** p205-211.

### Water Quality

**Particle and micro-organism removal in conventional and advanced treatment technology.**

Graveland A (1998) Water Science and Technology **37** (10) p125-134.

**Supplying high quality drinking water to remote communities in Scotland.**

Donn A, Odonnell J and Welch D (1998) Desalination **117** (1-3) p107-117.

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