



In this Issue:

Sydney Catchment Audit Report	1
US Ground Water Rule	4
Workshop Report	5
<i>WSAA Strategic Workshop on Viability Testing and Genetic Typing of Cryptosporidium Oocysts</i>	
News Items	10
Announcements	11
<i>EERE</i>	
<i>Australian Drinking Water Guidelines</i>	
<i>Health Stream Archive</i>	
From the Literature	14
<i>Aluminium</i>	
<i>Arsenic</i>	
<i>Cancer</i>	
<i>Disinfection Byproducts</i>	
<i>Gastroenteritis</i>	
<i>Helicobacter</i>	
<i>Legionella</i>	
<i>Microsporidia</i>	
<i>Mycobacteria</i>	
<i>Norwalk-like-virus</i>	
<i>Water Quality</i>	
List of Articles	20

Sydney Catchment Audit Report

Following the water contamination incidents in Sydney during late 1998, the management of water supplies for the city was restructured by the NSW state government (1). Responsibility for management of the catchment and storage dams was transferred from the Sydney Water Corporation to the newly formed Sydney Catchment Authority (SCA). The Act of Parliament establishing the SCA also required that an audit of the catchment be carried out within a five month interval of its formation.

The audit was designed to provide information to the SCA, state and local government departments and other relevant organisations to assist in the future management of the catchment, and in the development of specific programs for catchment improvement and pollution control. The audit will also be pivotal in the preparation of a Regional Environmental Plan for the catchment.

A team of experts led by Dr John Williams, Deputy Chief of CSIRO Land and Water, was appointed to perform the audit. The team was assisted by an Independent Reference Panel representing eleven organisations with broad expertise and first-hand knowledge of the catchment. The final report of the Catchment Audit was delivered to the NSW Minister for the Environment in December 1999 and publicly released in January 2000 (2).

The report provides a "snapshot" of the present state of the catchment and the many challenges that must be overcome in order to improve the protection of public health and ecosystem integrity. It also identifies a number of gaps in knowledge which currently hamper the development and assessment of management strategies. In many instances these relate not only to the specific circumstances of the Sydney

Editor	Martha Sinclair
Assistant Editor	Pam Lightbody

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

catchment area, but also to general limitations of existing knowledge of catchment ecology.

The Terms of Reference required that the Catchment Audit should compile and categorise information on the state of the catchment (in terms of attributes such as water quality, physical attributes, fauna and flora, cultural values etc), and the pressures to which the catchment is subject (in terms of human activities, land uses, natural processes etc).

In addition, the audit was expected to specifically provide:

- an inventory of what is known about the catchment (in terms of its state and available information sources)
- an assessment of the sufficiency of existing information
- an identification of information gaps
- an identification of the sources of pollution in the catchment

The audit team adopted the following process to provide a structured analysis of the state of the catchment:

- identification of hazards to the protection of public and catchment health
- identification of indicators which could be used quantify the risks associated with these hazards
- collection, processing and analysis of available data on these indicators
- assessment of both the condition of the land and water, and the risks to protection of public and catchment health based on available information
- identification of hazards for which no indicators are available
- identification of data and knowledge needed to provide indicators for such hazards
- integration of the findings under the four headings listed in the paragraph above
- recommendations for procedures and mechanisms for monitoring strategies to ensure required data is available and analysed for hazard and risk analysis
- identification of constraints to the use of this data and information in building risk management strategies and whole-of-catchment management

processes that are critical to protecting water quality and catchment health.

Prior to the audit, the SCA had assembled an extensive report summarising available information sources and data collections, and preliminary set of indicator measures had been developed in conjunction with experts from the CRC for Freshwater Ecology. The audit team carried out ground inspections of several areas of the catchment and made a comprehensive helicopter inspection of major river systems, as well as examining existing documentation. Landsat TM satellite imagery was also used to assess the state of the catchment area.

The audit team found that a very large volume of information was available on the catchment area in the form of numerous reports, investigations, and monitoring data. However there had been only limited attempts to integrate this knowledge to form a comprehensive picture of the condition of the whole catchment.

The SCA holds detailed information on the Special Areas (the "inner catchment" which was under the direct control of the Sydney Water Corporation), but has very limited knowledge on the remainder of the catchment (the "outer catchment" comprising over 70% of the total area). Much of the information on the outer catchment compiled for the audit was obtained from other State agencies and organisations.

Specific shortcomings in information identified by the audit included:

- Gaps in the natural resource information base for whole-of-Sydney water supply catchments. Effective management of the catchment will require the establishment of an extensive database linked to a geographic information system to document spatial, geological and land use characteristics.
- A gap in process knowledge of landscape, river, and ecosystem function. The SCA needs to develop models and tools to analyse and predict the behaviour of components of the catchment under different conditions, and build in-house expertise and understanding of these behaviours.

- Gaps in approach to general water quality and quantity monitoring. A large amount of monitoring data has been collected in the past but new methods are needed to present and analyse trends in a more informative way. In addition, more consideration is needed in the design of sampling programs to complement management programs and system modelling.
- Small but important data gaps. The audit team noted that no information was available on potential pollution from Commonwealth government facilities, and that there was no existing mechanism to collect information on projected changes in intensive farming activities. Information was also lacking on inputs of fertilisers and pesticides, and potential high risk areas for spillages such as locations of road intersection with streams.
- Microbial pathogens. A number of gaps exist in understanding of the sources, movement and survival of microbial pathogens in the catchment. More research is needed to define the importance of different human and agricultural sources.
- Sediments and related nutrient, sources, transport and delivery. Available information is insufficient to identify erosion, source of sediment transport and delivery across catchments, except on a broad scale which is inadequate to evaluate hazards and set priorities.
- Hazards associated with mining and extractive industries. Information on existing and abandoned mines is inadequate to assess risks and assist management for the majority of the catchment area.
- Gaps in knowledge of hazards associated with sewage, wastewater and solid waste disposal. Information on the location and extent of sewage discharges and overflows from treatment plants and septic tanks is incomplete, and this will hamper effective management.

The audit team recommended that the first priority for the SCA should be to assemble and organise the biogeographic spatial data for the catchment area. This should be followed by strategic planning of a program to fill the identified gaps in knowledge and information. The team also proposed an expanded set of indicators based on the findings of the audit, and recommended that these be further developed in

consultation with stakeholders and technical experts. It will be necessary to implement assessments of small areas in order to adequately describe the diverse nature of the catchments.

Overall, the report classified the state of the Sydney catchments as "reasonably good", with about 10% of the total area of 16,000 square kilometres considered to be "poor" while about 25% was rated as "excellent". However past management practices which concentrated heavily on protection of "Special Areas" around major storage reservoirs were deemed to be insufficient to maintain adequate protection of water quality. These areas are largely protected from residential and agricultural development but comprise less than 30% of the total catchment.

The audit team expressed the opinion that past dependence on the Special Areas to protect water quality had distorted the allocation of resources for monitoring and managing the catchment. Extensive agricultural and residential pressures on other areas of the catchment are contributing to increased hazards for water quality and catchment health, and a more integrated management strategy for the whole catchment area is now urgently required.

At present the SCA has limited powers governing regions outside the Special Areas, and SCA regulations can be overridden by a number of other agencies. The operations of at least 17 government instrumentalities have the potential to affect catchment health or water quality. The report concludes that successful implementation of a whole-of-catchment management plan will require the support of legislative power and policy to enable vigorous control of land use.

The audit team emphasise that adequate levels of resourcing, and active involvement and ownership by local government, state agencies and the community will also be essential. They recommend that the SCA builds in-house expertise and knowledge rather than relying on external consultants. The whole-of-catchment management plan must also be incorporated into the Regional Environmental Plan and other regional planning processes.

According to a report in the January 5 edition of the Sydney Morning Herald, the NSW government is already moving to strengthen the regulatory powers of the SCA. Applications for approval of developments in the catchment will soon have to include a water cycle management strategy explaining how water quality would be protected or improved by the development.

However, the NSW Opposition party has cautioned that granting broad additional powers as recommended in the Audit Report will result in the SCA becoming a "super-power agency" overriding existing local government, EPA and planning controls.

(1) Refer to Health Stream issues 11, 12 and 13 for reports on the contamination incidents and subsequent Sydney Water Inquiry.

(2) Audit of the Hydrological Catchments managed by the Sydney Catchment Authority. Final Report to the Minister for the Environment, NSW State Government, December 1999. CSIRO Land and Water. The report can be downloaded from:

<http://www.sca.nsw.gov.au/>



US Ground Water Rule

In recent decades regulators in the US have concentrated heavily on the microbiological health risks associated with surface water supplies, and have introduced progressively stricter microbiological standards for finished water and performance criteria for water treatment plants. In contrast, regulations for groundwater supplies are less stringent with no specific requirements for primary disinfection or maintenance of disinfectant residuals for groundwater sources not under the influence of surface water. However, increasing evidence of chemical and microbial contamination of groundwater supplies, and threats to reliability from over-pumping have resulted in an increase in regulatory attention (1).

The US EPA is now entering the final stages of revisions to the Ground Water Rule, which governs public groundwater supply systems. For the first time the Rule will require all public

groundwater supplies to be disinfected, even if they are not under the influence of surface water. In addition, substantial efforts are being made to expand and coordinate monitoring and management programs to improve understanding of the condition of groundwater supplies.

At least 400,000 public drinking water wells presently exist in the US, serving a population of about 110 million people. An additional 20 million people obtain their drinking water from private wells, making a total of 130 million (48% of the total US population of 268 million). Almost 95% of rural populations rely on groundwater for drinking and domestic use, and over 40% of water used for crop irrigation and livestock watering in the US comes from groundwater. Groundwater also contributes up to half of the water flow in surface streams.

Groundwater supplies have been traditionally viewed as having relatively low risks of microbiological contamination compared to surface water supplies, however a recent review of such supplies in the US has questioned this assumption (2). Researchers in the US EPA suggest that many groundwater supplies pose health risks to consumers, and advocate implementation of disinfection as a minimal protective measure for all groundwater supplies.

The authors review published studies on groundwater contamination and also note the existence of a substantial number of unpublished surveys. Although some studies have involved sampling of large numbers of wells, selection criteria were variable and in most cases only one sample was taken from each site. A large survey (244 samples from public wells) carried out by the American Water Works Association Research Foundation reported the presence of various indicators of faecal contamination in 50% of wells considered to be more vulnerable to contamination, and in 40% of wells considered less vulnerable.

In another survey of 30 US public wells thought to be vulnerable to contamination, 24% were positive for culturable viruses, more than 50% positive for coliphage, 50% positive for *E. coli*

and 70% positive for enterococci in at least one monthly sample over a one year period. Canadian researchers have also reported high rates of contamination, with the faecal indicator *Clostridium perfringens* found in 20% of 300 rural wells tested (3). These and other studies suggest that many groundwater sources are prone to faecal contamination but the fragmentary nature of the data makes it difficult to estimate the scope of the problem on a national level.

Groundwater supplies were responsible for 58% of the 614 drinking water related disease outbreaks in the US reported to the Centers for Disease Control and Prevention between 1971 and 1994. About 30% of these outbreaks were attributed to contamination of distribution systems, and the remaining 70% to contamination of the groundwater source. During 1995 and 1996 groundwater supplies were associated with 11 of 15 drinking water related outbreaks attributed to infectious agents (4).

In addition to recognised outbreaks reported to CDC, it is likely that substantial numbers of people are affected by unreported outbreaks or by small outbreaks that are not detected by health authorities. Some epidemiological studies have suggested that waterborne pathogens may be responsible for a significant portion of endemic gastrointestinal illness, although the evidence on this issue is not conclusive.

The authors of the recent review (2) believe that groundwater systems may now constitute a greater threat to public health than surface waters because of the lower rates of use of disinfection and absence of filtration in groundwater supplies. In order to derive an estimate the possible magnitude of the problem, they developed a quantitative risk assessment model based on available knowledge of groundwater contamination.

This model assumed faecal contamination rates between 7% and 46% of wells, presence of human infectious viruses in 46% of contaminated wells, a population of 27 million people drinking predominantly from undisinfected groundwater systems, and dose-response models for rotavirus

infection. This model resulted in an estimate of 890,000 to 5.9 million illnesses per year attributable to undisinfected groundwater sources, associated with a possible mortality of 1,400 to 9,400 per year (assuming a 1% death rate among elderly people who suffer gastroenteritis).

A number of approaches for controlling microbial contamination of groundwater sources were also reviewed and available evidence on their efficacy was examined. There appear to have been few assessments of well-head protection programs, but the results suggest that such measures have not reduced contamination rates. However US states which consider hydrogeological criteria for siting wells had fewer reported violations of the Total Coliform Rule (TCR) than states which did not use these criteria. Analysis of violation rates for the TCR vs the proportion of groundwater supplies which are disinfected in each state showed a marked inverse relationship. The ten states with highest rates of disinfection showed an 18% violation rate over 5 years, whereas the ten states with the least disinfection had a violation rate of 38%.

The authors conclude that while considerably more information is needed to establish the extent and health impact of microbial contamination of groundwater, the introduction of disinfection for all groundwater systems would be "prudent public health policy".

(1) Safe Drinking Water Act, Section 1429 Ground Water Report to Congress. Office of Water, US EPA. EPA-816-R-99-016 October 1999.

(2) Current knowledge on groundwater microbial pathogens and their control. Macler, B. A. and J. C. Merkle (2000). Hydrogeology Journal - Special Issue: Groundwater and Microbial Processes, **8** (1) p29-40.

(3) Contamination of rural drinking water wells by fecal origin bacteria - Survey findings. Conboy, MJ and MJ Goss (1999). Water Qual Res J Canada **34**: 281-303.

(4) Surveillance for Waterborne Disease Outbreaks- United States, 1995-1996. (1998). MMWR **47**(SS-5): 1-34.



Workshop Report

WSAA Strategic Workshop on Viability Testing and Genetic Typing of *Cryptosporidium* Oocysts.

9 & 10 March 2000, Sydney

This workshop was attended by over 20 invited participants, representing a broad spectrum of Australian water industry, research and public health interests. International guests included Dr George Di Giovanni (American Water Works Service Company), Dr Rachel Chalmers (Director of the *Cryptosporidium* Reference Laboratory, UK) and Dr Jim McLauchlin (Public Health Laboratory Service, UK). The workshop produced a series of initiatives to build a strong collaborative *Cryptosporidium* research program in Australia, with potential for expansion to an international level.

This meeting was prompted in part by a workshop held at Tadley Court in the UK during August 1999 (1). The Tadley Court workshop discussed observations that *Cryptosporidium* oocyst sources and preparation methods may impact on viability, and highlighted the problems associated with the use of different (and often poorly described) methods in published studies which severely limited the comparability of results. The participants developed a number of best practice protocols for oocyst preparation, cell culture, disinfection and treatment studies, reporting of results, and quality assurance and quality control for *Cryptosporidium* research.

Dr John Langford, Executive Director of WSAA, opened the Sydney workshop with a brief introduction to WSAA and a review its research program on a range of issues relating to water quality and human health. WSAA was a founding partner in the CRC for Water Quality and Treatment, and is co-funding a number of projects including the Water Quality Study (a randomised controlled trial on the effect of drinking water treatment on gastroenteritis), and Case-control studies of risk factors for cryptosporidiosis. In addition to its involvement in the CRCWQT, WSAA also conducts an independent research program. The process of developing the WSAA research agenda involves strategic workshops to discuss industry needs, define gaps in current

knowledge, and assess the feasibility of different research approaches.

After outlining the five specific objectives of this workshop on viability testing and genetic typing of *Cryptosporidium* oocysts, Dr Langford then introduced Dr George Di Giovanni to lead the discussion on the first objective.

Objective 1 - to define the research and technology transfer necessary to refine and establish in vitro procedures for the maintenance of *Cryptosporidium parvum* isolates of both the human and cattle genotypes (Genotype 1 and 2).

Dr Di Giovanni has successfully combined cell culture and PCR techniques to develop a method for the specific detection of *C. parvum* oocysts that are infectious for humans (2). The method utilises filtration and immunomagnetic separation to purify oocysts from environmental samples, followed by inoculation into human HCT-8 enterocyte cell monolayers in microtitre tray wells. After a 72 hour incubation to allow replication of infectious oocysts within the human cells, the monolayers are washed to remove any unexcysted oocysts, then the cells are lysed and PCR is used to amplify a 361 basepair DNA product from the *C. parvum* heatshock protein (hsp70) gene. The amplified segment is then DNA sequenced to determine the genotype.

The cell culture method permits the growth of both the Type 1 (human) and Type 2 (cattle) genotypes of *C. parvum* and has been used to test the three Type 2 isolates used in human volunteer studies. These three isolates showed large differences in infectivity in the human volunteers, and this correlated strongly with infectivity in HCT-8 cell cultures. Thus the technique appears to represent a relevant laboratory model for human infection. However, the protozoa are not able to form new oocysts to complete the entire infection cycle, and the cell cultures can be maintained only for a limited time. Nevertheless, this method offers a more rapid and lower cost alternative to animal infection studies.

The cell culture technique is sufficiently sensitive to detect a single viable oocyst, and has been

successfully employed to detect viable oocysts in finished water, raw water and filter backwash samples. Ongoing experimental work is aimed at optimising excystation and cell culture conditions, and adapting the method to yield semi-quantitative information on viable oocysts numbers so that it can be more easily applied to disinfection studies.

The workshop participants agreed that coordinated efforts should be made to establish this cell culture technique in Australian laboratories, and carry out inter-laboratory comparisons to ensure that results were reproducible. The following strategy was suggested for implementation:

- development of specifications for laboratories to participate in the program (these would include facilities for cell culture work, willingness to collaborate, willingness to follow the Tadley Court protocols, and willingness to help others establish the technique).
- advertisement for Expressions of Interest
- selection of several laboratories to participate
- implementation of a coordinated research program initially using the well characterised Iowa (Type 2) strain to establish the technique and ensure inter-laboratory comparability. This would be followed by inter-laboratory exchange of human *Cryptosporidium* isolates (Type 1), and testing of the cell culture technique for these.
- organisation of a workshop to disseminate results and enable transfer of the technique to other laboratories.

Objective 2 - to develop strategies for the evaluation of RT-PCR and FISH procedures for their value as a routine procedure for their assessment of oocysts viability.

Dr Duncan Veal from Macquarie University and Dr Paul Monis from the Australian Water Quality Centre outlined the properties of the two methods under discussion. These procedures are already in use in a number of Australian laboratories as surrogate markers for oocyst viability or infectivity, however they have not yet been validated against cell culture or animal infection methods. Some work on validation is presently underway in the US and the UK.

The FISH method detects the presence of ribosomal RNA sequences (rRNA) which are believed to degrade relatively quickly after oocysts become inviable. As rRNA contains both highly conserved and highly variable regions, it is possible to use different probes to detect either all *Cryptosporidium* species, or *C. parvum* in particular. The results can be scored using an epifluorescence microscope or using flow cytometry, giving quantitative results on the number of "viable" oocysts.

The RT-PCR method detects messenger RNA (mRNA) which codes for the heatshock protein (hsp70). Again, this molecule is believed to degrade relatively quickly after oocysts become inviable. The method has the ability to detect either all *Cryptosporidium* species, or *C. parvum* specifically depending on the probe used. The outcome is essentially a presence /absence result for "viable" oocysts without quantitation.

The participants agreed that following establishment of the HCT-8 cell culture technique in Australia, a study should be carried out to compare the results of FISH, RT-PCR and cell culture methods. This should be carried out in a blinded fashion with samples of fresh oocysts, killed oocysts and aged oocysts (which would be expected to have declined in viability) from several isolates. In order to provide statistically reliable results, it was recommended that a biometrician be involved in the study design, and that further discussions be held when a draft protocol was available for consideration.

Objective 3 - to develop strategies for a multi-centre trial within Australia and overseas to compare currently existing PCR based detection procedures for *Cryptosporidium* with the aim of evaluating broad applicability in terms of specificity and sensitivity.

and;

Objective 4 - to develop strategies for a multi-centre trial within Australia and overseas to compare currently existing PCR based genotyping techniques in order to determine the most useful genetic loci.

Discussion on these objectives was introduced by Dr Una Morgan of Murdoch University, who

began by outlining the requirements for a testing procedure in terms of sensitivity, reproducibility and speed. A decision needs to be made on whether the method should be able to detect all species of *Cryptosporidium*, all genotypes of *C. parvum*, or only those genotypes currently known to infect humans with normal immune systems (ie Genotypes 1 and 2). Ideally the method should also have the capability to determine the genotype.

Dr Morgan then summarised the current state of knowledge on *Cryptosporidium* genotyping. The taxonomy of this organism is currently under review as increasing knowledge from molecular characterisation reveals details of phylogenetic relationships. For *C. parvum* it is likely that some of the currently recognised genotypes will eventually be designated as separate species. At present 7 distinct major genotypes are classified within *C. parvum*; Type 1 (human), Type 2 (cattle), marsupial, pig, mouse, ferret, and dog. A minor variant of Type 1 occurs in monkeys. The dog genotype is soon likely to be reclassified as a separate species (*C. canis*), while the cat genotype is already recognised as such (*C. felis*).

A number of genetic loci have been examined for their ability to distinguish between different species of *Cryptosporidium*, and to discriminate between major genotypes within a species. There have been some discrepancies in results reported by different laboratories, perhaps due to different methodology. Overall, it appears that the 18S rRNA gene and the Hsp70 gene provide the best markers for reliably distinguishing between species and major genotypes.

Extensive efforts have also been made by a number of laboratories to develop markers for distinguishing between isolates within a genotype, however the results have been disappointing. Genome sequencing projects are underway, with the aim of determining the entire sequence of the Iowa (Type 2) isolate and at least 65% of the sequence of the NEMC1 (Type 1) isolate. This knowledge may assist in designing new probes for genotyping individual isolates.

After further discussion it was agreed that collaborating Australian laboratories would

undertake to perform an analysis with standard markers, primers, and a reference strain (and/or DNA clones) when characterising isolates in order to provide consistent data for comparison. These standards were agreed to comprise the 18S rRNA and Hsp70 markers, with the Iowa strain or clones of its DNA. Collaboration will also be sought in the UK via the National *Cryptosporidium* Research Steering Committee and in the US via AWWARF. It was agreed that consideration should be given to establishing a database of verified *Cryptosporidium* DNA sequence data to assist the collaborative research effort.

On the topic of avenues for seeking new markers to distinguish between isolates, Dr Duncan Veal suggested that the science of "proteomics" might offer some promise. This methodology involves the automated analysis of differences in protein content between isolates. This may enhance the probability of finding strain-specific markers. It was agreed that a preliminary research proposal for this approach should be developed.

Objective 5 - to explore strategies for determining the prevalence and distribution of human infectious and non-infectious genotypes in different water sources, and in populations of human and animal hosts.

Dr Andrew Thompson from Murdoch University introduced this topic and highlighted the need for a diverse collection of isolates from animal, human and environmental sources in order to gain the maximum knowledge from genotyping studies.

Dr Jim McLauchlin then presented the findings of genotyping studies done in the UK by the Public Health Laboratory Service. Analysis of isolates from eight drinking water *Cryptosporidium* outbreaks in the UK demonstrated that five outbreaks were due to Type 1 isolates (indicating human faecal pollution) while three were due to Type 2 isolates (human or animal faecal pollution). For five swimming pool related outbreaks examined, two were of Type 1, two were of Type 2 and one was mixed Types 1 and 2.

Seasonal trends in prevalence in sporadic cases (not related to outbreaks) showed that the Type 1 genotype is rarely isolated in winter, while the Type 2 genotype is found all year round. The incidence of reported cases and the ratio of Type 1 and Type 2 isolates varies in different regions. Data on farm animal infections show a consistent peak of infection in sheep during springtime (lambing season), while in cattle infection peaks occur both in spring and in autumn.

Overall, the two major *C. parvum* genotypes (Types 1 and 2) account for at least 96% of human infections in the UK. An apparently novel genotype (Type 3) has been found recently but has not been well characterised.

The workshop discussions then turned to avenues for obtaining a broader range of *Cryptosporidium* isolates for study:

Human sources Some participants at the workshop have established ongoing relationships with hospitals or pathology laboratories, but these sources are limited. A number of possible mechanisms to obtain isolates were discussed:

- Request pathology laboratories to forward *Cryptosporidium*-positive faecal specimens to researchers after routine pathogen testing had been completed. Such specimens would normally be discarded unless the lab was participating in a research project.
- Request pathology laboratories to forward faecal specimens which had not been tested for *Cryptosporidium* (in most labs only a minority of faecal specimens are tested for this organism), then test these for *Cryptosporidium*. This was seen as presenting ethical difficulties concerning patient consent and obligations to notify patients and health authorities of positive results.
- Actively seek to collect and test faecal specimens from settings where *Cryptosporidium* infection rates might be expected to be high (eg childcare facilities). This would require ethical approval and informed consent from parents. Patients and health authorities would need to be notified of positive results.

It was agreed that the first option should be explored as the most simple and lowest cost alternative. Dr Geoff Hogg of Melbourne University suggested that the cooperation of the Public Health Laboratory Network should be sought initially, and then commercial pathology labs should be approached. *Cryptosporidium*-positive faecal specimens reported to Health departments in Victoria and South Australia are already being collected as part of a CRC for Water Quality and Treatment Case-control study.

Environmental sources Some Australian water authorities are testing environmental samples for *Cryptosporidium*, but in many cases the entire sample is used in the test procedure. Taking duplicate water samples is expensive, and the low oocyst numbers and often poor recovery rates, oocysts may not be recovered from both samples.

Dr Jim McLaughlin reported that he had achieved some success with attempts to remove oocysts from slides after microscopic examination and genotype them. Dr Chris Saint and Dr Paul Monis from the Australian Water Quality Centre agreed to carry out preliminary experiments of this nature to see if a reliable technique could be developed and report back to the group.

Dr Duncan Veal noted that the SCA had agreed to forward positive samples from their sampling program to him for genotyping, and Dr David Roser from the University of NSW undertook to seek similar cooperation from water authorities participating in the CRCWQT Pathogens in Catchments Project.

Animal strains Participants with expertise in this area reported that tests for *Cryptosporidium* are rarely done in routine veterinary practice. Most isolates of this nature have to be obtained from specific research projects. Some Australian water authorities are supporting research programs to examine the carriage of *Cryptosporidium* in catchment animals.

Conclusion Dr John Langford concluded the workshop by summarising the agreed strategy and actions developed for each objective, and thanked participants for their valuable input. The proposed

research strategy will now be presented to the WSAA Research Committee for consideration and further development.

(1) Towards a standardised experimental design for viability and inactivation studies. Report on a Workshop on *Cryptosporidium* and Water Chaired by Professor Ian Bouchier Held at Tadley Court, Tadley, Hampshire on 11-12 August 1999.

<http://www.dwi.detr.gov.uk/pubs/>

(2) Detection of infectious *Cryptosporidium parvum* oocysts in surface and filter backwash water samples by immunomagnetic separation and integrated cell culture-PCR. Di Giovanni, G. D., F. H. Hashemi, et al. (1999). *Appl Environ Microbiol* **65**(8): 3427-32.



News Items

Law suits over E. coli outbreak

The E. coli O157:H7 outbreak that hit the Washington County Fair in August last year has resulted in lawsuits seeking millions of dollars in damages. Over 1,000 people became ill and two people died after drinking unchlorinated well water during the Fair. One of several wells on the site is believed to have been contaminated by waste seepage or runoff from a nearby dairy farm after heavy rains.

The Fairground is operated by a small non-profit community group which holds public liability insurance of only \$1 million. The group is presently engaged in a legal dispute with the insurance company which is arguing that a policy clause exempting damage from storm and wastewater pollution of sewer systems or streams is applicable in this instance.

The outbreak has highlighted the risks faced by many small water supply systems in the US, and variations in state requirements for insurance coverage for system operators. It is believed many small to medium operators have inadequate insurance cover and seldom hold policies covering their officers and directors. This may leave individuals personally liable for damages settlements in cases such as this.



Parents advised to sue over water

A British pediatrician has advised parents to sue schools which do not provide drinking fountains for children. Dr Trevor Brocklehurst of the St James University Hospital in Leeds said that many schools have removed water fountains and substituted softdrink vending machines in their place, leaving children with little opportunity to obtain plain water. Dr Brocklehurst has raised the issue with the Leeds Health Authority, claiming that children he is treating for urinary tract infections are being placed at risk of complications by lack of access to water at school. The Leeds Health Authority is undertaking a study on the extent of the problem, and says it is working with local education authorities to ensure drinking water is readily available at all schools.



US retains copper goal

The US National Research Council has released a report recommending that the current maximum contaminant level goal (MCLG) of 1.3 mg/L should be retained by the EPA. Water supplies where the 90th percentile of first flush samples exceeds the MCLG may be required to take remedial action. The Council was asked to review the scientific and technical basis for the level after epidemiological studies in Nebraska and Delaware failed to show adverse effects in people consuming drinking water with high copper levels.

Copper is an essential human nutrient but can also cause acute gastrointestinal symptoms and longer term toxicity when ingested at higher doses. Children are more vulnerable to copper toxicity than adults, and people suffering from several genetic conditions may be affected even by low levels. The committee concluded that conventional risk assessment using chronic toxicity endpoints and safety factors was not applicable in this case because of the essential nature of copper, its metabolic regulation and the narrow range of acceptable intake levels. Further research is needed to better define vulnerable groups and to estimate total copper intake from drinking water and other sources.

www.nap.edu

EERE 2000

The 4th Annual Australian Environmental Engineering Research Event provides postgraduate students of Environmental Engineering and related disciplines an opportunity to present and discuss their work in a friendly, informal atmosphere. A selection of prominent international and local speakers has been invited.

The Event will be held in Victor Harbor, South Australia, 21 - 24 November 2000. The theme of the event, "*Environmental disciplines working together for a sustainable future*", will address students from a wide variety of disciplines. One of the highlights of previous events has been the lateral communication between postgraduate researchers of different scientific and engineering disciplines, and we are keen to maintain this tradition.

Thus we encourage any postgraduate students working in the environmental field to attend, whether they are Engineers or Scientists. Postgraduate students interested in attending must either present a poster presentation or a platform presentation. There is a call for abstracts, which are due 19th May 2000. Sponsorship opportunities are currently available.

If you would like more information on the Event please contact the Event Organisers or visit our website at www.waterquality.crc.org.au/eere2000

Lionel Ho

CRC for Water Quality and Treatment
Private Mail Bag 3
SALISBURY SA 5108

Phone: (08) 8259 0365

Fax: (08) 8259 0228

Email: lionel.ho@sawater.sa.gov.au

Rachel Prince

School of Engineering and Science
Swinburne University of Technology
Mail 38, PO Box 218
HAWTHORN VIC 3122

Phone: (03) 9214 8639

Fax: (03) 9819 6443

Email: rprince@swin.edu.au

Sam Brooke

CRC for Water Quality and Treatment
Private Mail Bag 3
SALISBURY SA 5108

Phone: (08) 8259 0347

Fax: (08) 8259 0228

Email: sam.brooke@sawater.sa.gov.au

The CRC for Water Quality and Treatment is a Gold Sponsor of EERE 2000.

News Items (continued)

US EPA asks for delay in chloroform case

The US EPA has asked the District of Columbia Court of Appeal to postpone hearings on the case brought against it by the Chlorine Chemistry Council. As reported in Health Stream Issue 16, the CCC has filed a suit asking the Court to set aside the EPA Maximum Contaminant Goal Level of zero for chloroform, and order the EPA to set a non-zero MCLG based on scientific evidence. The EPA is seeking to delay the case on the grounds that the zero MCLG was set as an "interim risk management decision" in response to a Congressional deadline, while additional scientific information was still being sought.

New evidence in the form of a report from the Science Advisory Board is now available, and the EPA has argued that proceeding with the current court case would be an inefficient use of time and resources for all parties.



Water Supply in Engineering Top 20

Water supply and distribution has been recognised as one of the top engineering achievements of the 20th century by the US National Academy of Engineering. Water supply ranked 4th in the list of achievements after Electrification, Automobiles and Airplanes.

www.greatachievements.org

National Health and Medical Research Council

Revision of the NHMRC/ARMCANZ Australian Drinking Water Guidelines

In 1997/98, NHMRC/ARMCANZ commenced a rolling revision of the Australian Drinking Water Guidelines (ADWG). This rolling-revision provides an opportunity to revise individual water quality parameters each year to ensure the guidelines represent the most up to date scientific understanding.

The NHMRC/ARMCANZ Drinking Water Coordinating Group is currently seeking advice in relation to priority areas to be considered for the 2000/01 phase of the ADWG rolling-review. The following information outlines the areas that have been revised since 1998.

In 1998/99 the following areas were reviewed:

- *Cryptosporidium*
- *Giardia*
- Radionuclides
- Atrazine
- Cyanobacteria
- Boron

The revised fact sheets are due to be completed in 2000 following a final round of public consultation.

The 1999/2000 review program included:

- Aluminium
- Arsenic
- Copper
- Taste and Odour
- Turbidity
- Coliforms
- *Burkholderia Pseudomallei*
- Drinking Water Treatment Chemicals
- Water Quality Management

The respective fact sheets are also due for completion in 2000 following a final round of public consultation.

The NHMRC/ARMCANZ Drinking Water Coordinating Group is currently considering developing a work program for 2000/01 and would welcome input into establishing priority issues for consideration during the ADWG rolling-review process. Advice is being sought on issues that should be considered during the forthcoming year.

If you consider:

- there are individual water quality parameters currently in the Guidelines that require urgent revision, or
- there are drinking water quality issues that are not in the current Guidelines that should be included as part of the 2000/01 revision,

please provide relevant advice and information to support the requirement for revision. Submissions are to be forwarded to:

Mr Phil Callan
Assistant Director
Health Advisory Unit
Office of the NHMRC
GPO Box 9848
CANBERRA ACT 2601
Fax: (02) 6289 9190
EM: philip.callan@health.gov.au

Closing date for submissions is **5 May 2000**.

Coming soon

the Australian Drinking Water Guidelines on the Web

The NHMRC/ARMCANZ *Australian Drinking Water Guidelines* (ADWG) provide the Australian community and the water supply industry with guidance on what constitutes good quality drinking water.

The ADWG will soon be available to download in PDF format from the Web site of the NHMRC at:

www.nhmrc.health.gov.au/publicat/synopses/eh19syn.htm

Following its endorsement in 1996, the ADWG has been subjected to a Rolling Revision process that ensures the Guidelines represent the latest scientific evidence in relation to good quality drinking water. From time-to-time, as sections of the Guidelines are reviewed, the Web site will be updated to provide the latest information.

The production of the PDF version of the ADWG has been organised and sponsored by the **Cooperative Research Centre for Water Quality and Treatment** as a service to the Australian water industry.

Links to the ADWG and reports on the progress of the Rolling Revision can be found on the Web site of the CRCWQT:

www.waterquality.crc.org.au

Health Stream Archive

- Can't remember what issue that important article was in?
- Need to quickly check some facts?
- Want an overview of research on a specific topic?

Search the Health Stream Archive to find what you need - a full archive of articles, literature summaries and news items can now be searched on the Web site of the CRC for Water Quality and Treatment:

visit us at www.waterquality.crc.org.au
and click on **Search this site**

Email Notification Lists

Readers who prefer to access the Web version of **Health Stream** can now receive email notification whenever a new issue is placed on our Web site. This service is also available for our general newsletter **Water Quality News**.

Check the **Publications** section on our Web site for details of how to register.

From the Literature

Aluminium

Bioavailability of Al in alum-treated drinking water.

Stauber JL, Florence TM, Davies CM, Adams MS, Buchanan SJ. (1999) J AWWA **91**(11) p84-93.

This paper describes the study previously reported in Health Stream (Issue 12). The relative bioavailabilities of aluminium (Al) in food and in municipal alum-treated drinking water were determined by measuring Al uptake into blood plasma, and Al excretion in urine of volunteers. It was found that the bioavailability of Al from water (0.37 percent) was similar to that of food (0.28-0.64 percent), which confirms that Al from drinking water is not more easily absorbed than Al from food. Therefore Al from drinking water was not likely to contribute to the incidence of Alzheimer's disease. It was also estimated that drinking 1.6L/d of ATW containing 140 microgram/L Al would only contribute 0.4-1.1 percent of the lifetime body burden of Al.

Addendum on the Camelford Incident.

In our last issue we summarised a paper by Altmann et al. on a study of cerebral function in people resident in Camelford UK when the drinking water supply was contaminated with high levels of aluminium sulphate. We were unable to locate information on the potential exposure levels during this incident.

Dr Alan Godfree of North West Water UK has kindly supplied the following information:

The report of Lowermoor Incident Health Advisory Group (Chaired by Prof Dame Barbara Clayton) published in July 1989 gives information on water quality. Para 6 states that "As a result of the Lowermoor incident, it is likely that for a period of up to three days consumers were supplied with acidic water of pH as low as 3.9-5.0. An aluminium content of up to 620 milligrammes per litre and a sulphate concentration of up to 4500 milligrammes per litre were recorded." The report goes on to say that "The level of aluminium fell below 1 milligramme per litre in the second phase of the

incident, but the EC MAC of 0.2 milligrammes per litre was only achieved after a period of intensive cleaning and flushing".

In assessing exposure, the Health Advisory Group assumed that consumers were exposed to aluminium concentrations of 10-50 milligrammes per litre for between one and three days.

Arsenic

Excretion of arsenic in urine as a function of exposure to arsenic in drinking water.

Calderon RL, Hudgens E, Le XC, Schreinemachers D, Thomas DJ. Environ Health Perspect (1999) **107** p663-667.

This study examined whether the excretion of arsenic in urine is a biomarker for exposure to inorganic arsenic (InAs) in drinking water. Subjects were recruited from residents of Millard County, Utah who had not changed their place of residence in the last 5 years. Half of the subject were residents in a town supplied by well water with low InAs concentration (less than 20 microgram/L). The rest of the subjects lived in surrounding areas with higher concentrations of InAs in well water (more than 20 microgram/L). Each subject completed an exposure assessment questionnaire and answered questions regarding demographics, medical history, and length of residence in their present home as well as use of drugs, alcohol, or tobacco and daily water consumption. A diet diary was kept for 6 consecutive days and arsenic intake from drinking water estimated.

Males comprised 56% of subjects, and 44% of subjects were younger than 18 years. Ninety-six study subjects provided first morning void urine samples for 5 consecutive days. On one of the days a 24-hr urine collection was done. Tap water samples were collected in the homes of subjects and analysed for InAs. Concentrations of InAs in the home drinking water ranged from 8 to 620 microgram/L.

The concentrations of As in urine were found to be stable throughout the day. There was also very

little individual day-to-day variation in As concentration in urine. Urine concentration did not vary by gender, however an age dependent difference was seen. Concentrations of As in drinking water were a better predictor of the concentration of As in urine than the estimated intake of As from drinking water. The authors suggest that repeated urine samples may not be needed to give good estimates of InAs exposure, and measurement of InAs in drinking water may be a useful substitute for estimating individual exposure. The subjects may have reached a "steady state" of arsenic intake and excretion due to continuous exposure.

Comment Participants in this study were members of the Mormon Church and did not consume alcohol or caffeine, and were non-smokers. The observations in this population may not be applicable to the broader community as both alcohol and caffeine affect urinary output.

Arsenic in groundwater and health problems in Bangladesh.

Karim M. Water Research (2000) **34** p304-310.

This paper reviews the contamination of groundwater with arsenic in Bangladesh by examining the tubewell (bore well) contamination and the related health impacts. Records from over 30,000 tubewell samples were analysed. Arsenic levels exceeded the WHO guideline value for drinking water of 0.01 mg/l in 55 of the 64 districts of Bangladesh. In 52 districts the arsenic contamination in several wells was considerably above the Bangladesh drinking water standard of 0.05 mg/l. Among the 52 districts, 17 had maximum arsenic levels in groundwater exceeding 1 mg/l.

The affected districts are mainly crop producing areas where most residents are involved in manual agricultural labour, and average daily water intake for adults has been estimated at 5-6 litres. Additional arsenic is also consumed in food prepared with contaminated water. Despite a high prevalence of arsenic related skin lesions and other illnesses, public awareness of the hazard is low.



Cancer

Associations between stomach cancer incidence and drinking water contamination with atrazine and nitrate in Ontario (Canada) agroecosystems, 1987-1991.

Van Leeuwen JA, Waltner-Toews D, Abernathy T, Smit B, Shoukri M. Int J Epidemiol. (1999) **28** p836-840.

This ecological study was undertaken to investigate associations between cancer incidence and drinking water contamination with atrazine and/or nitrate, and related agricultural practices in the Ontario agroecosystems for the years 1987-1991. Both nitrate and atrazine are chemicals used in modern agriculture and have contaminated groundwater in the Ontario agroecosystem. Some epidemiological studies have suggested possible associations between these two chemicals and certain cancers.

Cancer data was obtained from the Ontario Cancer Registry for cancer of the stomach, colon, ovary, bladder and central nervous system and non-Hodgkin's lymphoma. The cancer data was aggregated into 40 ecodistricts. Cancer incidence rates were calculated by dividing the number of new cases of cancers in each ecodistrict during 1987-1991 by the number of person-years of population-at-risk during this time period. The cancer incidence rates were age standardised using sex-specific 5-year age groups. Data on water contamination, and agricultural practices in each district was obtained from government surveillance programs. Average values for confounding variables such as alcohol consumption, smoking, education level, income, and occupational exposures were estimated from census and health survey data.

The atrazine contamination levels ranged from 50-649 ng/l, the maximum acceptable concentration (MAC) being 60,000 ng/l. Atrazine was significantly associated ($p < 0.05$) with increased stomach cancer incidence and decreased colon cancer incidence in both males and females. Atrazine levels appeared to have reduced the colon cancer incidence, although there is no known biological reason for such an

effect. The authors suggest there may be interaction between social and biological variables such as higher vegetable production and consumption in areas with higher atrazine use.

The nitrate contamination levels ranged from 0-91 mg/l with the MAC of 10 mg/l. Nitrate was negatively associated with stomach cancer incidence in males and females. This result is in contradiction to other studies, which have found positive associations or correlations with drinking water nitrate levels and stomach cancer. These earlier studies however, did not consider the possible interactions or complex feedback loops, which occur in an agroecosystem.

Comment This study is limited by the fact that the individual exposure levels of people with and without cancer were not examined, and individual confounding factors (smoking, diet) were also not determined. The time frame of exposure measurement is also not appropriate - exposure levels for ecodistricts were estimated from levels of atrazine and nitrate measured in water during 1991/1992, and pesticide and fertiliser use from surveys during 1983 to 1988. However the cancers examined here were diagnosed between 1987 and 1991, and could not have been attributable to such recent exposures. Exposure data for 10 to 30 years prior to diagnosis would be more relevant for these cancers.

Comparison of trace elements in drinking water between high and low incidence districts of gastric carcinoma.

Liu XJ, Liu QQ, Cheng J, Zhang LP, Mu BF, Xue ZN, et al. Nuclear Instruments & Methods in Physics Research Section B-Beam Interactions with Materials & Atoms. (2000) **160**(1) p167-171.

This ecological study analysed the difference between trace elements in drinking water collected from areas with high incidence and low incidence of gastric carcinoma. Drinking water samples were collected from Shewopo town in Qixia county in China where mortality from gastric carcinoma is high and from Shenshan town in Cangshan county where mortality is low.

The concentration of titanium (Ti), vanadium (V), iron (Fe), copper (Cu) and strontium (Sr) were significantly higher in the drinking water from the high cancer incidence county. However, the concentration of arsenic (As) was significantly higher in the low cancer incidence county.

The authors comment that there have been no previous reports of an association between V and cancer, and few reports that Ti and Sr are correlated positively with cancers. However a number of studies have reported a correlation between high levels of Fe and Cu in drinking water and cancer incidence.

Esophageal cancer mortality and total hardness levels in Taiwan's drinking water.

Yang CY, Chiu HF, Cheng MF, Tsai SS, Hung CF, Lin MC. Environ Res (1999) **81** p302-308.

The aim of this study was to examine the relationship between the total hardness levels in drinking water from municipal supplies and death from esophageal cancer. The hardness of drinking water is mainly determined by its calcium and magnesium content.

A total of 322 municipalities in Taiwan were analysed. The Bureau of Vital Statistics of the Taiwan Provincial Department of Health provided data on all deaths of Taiwan residents from 1987 to 1996. A case group was formed consisting of all eligible esophageal cancer deaths occurring in people between 50 and 69 years. A control group consisted of all other deaths caused by malignant neoplasms of stomach, colon, rectum, rectosigmoid junction and anus and pancreas. Control subjects were randomly pair matched to the cases by sex, year of birth and year of death. The Taiwan Water Supply Corporation provided information on the total hardness of each municipality's drinking water. The source of cases and controls hardness exposure via drinking water was assumed to be their municipality of residence, this was identified from death certificates.

A total of 2084 cases and 2084 controls with complete records were included in the study. The percentage of cases and controls with hard

water (over 150mg/L) was 38.3% and 42.3% respectively, moderately hard water (between 75 and 150mg/L) 28.8% and 33.2% respectively and soft water (less than 75mg/L) 32.9% and 24.5%. Odds ratios and 95% Confidence Interval for esophageal cancer relative to individuals who had hard water were 0.96 (95% CI=0.82 1.09) for people who lived in places served by moderately hard water and 1.42 (95% CI= 1.22 1.66) for people who had soft water.

A significant increasing trend in the odds ratios for esophageal cancer with decreasing levels of hardness was found. The results suggest that hard water seems may have a protective effect against esophageal cancer, however further studies are required to investigate the water intake of individuals, and confounding factors such as tobacco and alcohol consumption.



Disinfection Byproducts

Chlorination disinfection byproducts in water and their association with adverse reproductive outcomes: a review.

Nieuwenhuijsen, M. J., M. B. Toledano, et al. (2000). *Occup Environ Med* **57**(2): 73-85.

This article reviews the toxicological and epidemiological evidence for an association between disinfection byproducts (DBPs) and adverse reproductive outcomes. The formation of DBPs is briefly described, and it is noted that the trihalomethanes are usually the most abundant byproducts of water chlorination. Several other classes of DBP compounds are also formed, but these are less commonly monitored.

Experiments in laboratory animals (mostly rodents) have shown that exposure to high levels of some DBPs can cause reproductive or developmental toxicity. In these experiments exposure levels have ranged from 10,000-fold to greater than a million-fold higher than the levels normally found in drinking water. In addition, DBPs have generally been administered to test animals as a single daily dose by gavage, rather than being consumed over the course of a day. In most studies the observed effects appear to be due to generalised toxicity (eg reduced foetal body

weight), but in some instances foetal malformations have been observed. A number of animal studies have also reported adverse effects on male and female fertility. The biological mechanisms by which DBPs affect reproduction or foetal development are not well understood, and a number of DBPs have not yet been studied for such effects.

Ten epidemiological studies on DBPs and human reproductive outcomes published between 1992 and 1999 are summarised. The authors excluded 4 papers relating to Santa Clara County in California where contamination of groundwater by trichloroethane (not a DBP) has been associated with increased risks of spontaneous abortion and congenital anomalies.

A wide range of reproductive outcomes have been studied including spontaneous abortion, stillbirth, low birthweight, intra-uterine growth retardation, preterm delivery and a range of congenital malformations. Some studies have shown statistically significant increases in risks for some adverse outcomes but no consistent pattern is evident across studies. In most cases, confidence intervals have been wide and dose-response trends were not seen.

Comparison of the studies is difficult because of the different exposure indices and outcome measures used. In three studies exposure to different levels of DBPs was inferred from the mothers residence at time of delivery, and the type of water source (surface water vs groundwater) or the type of water treatment (chlorinated vs chloraminated vs undisinfected). Four studies have used the mothers residence plus routine THM measurements by water companies as an index of exposure, however in one instance the water measurements were done two years prior to the pregnancies under study. Only three studies have used individual interviews or questionnaires to estimate water intake by women, and two of these also included estimates of exposure to volatile DBPs through showering or swimming. Even in these cases, the exposure levels were inferred from measurements taken by the water company at 3 monthly intervals at a few sites in the water distribution system.

Overall, the available evidence suggests the risks, if any, are small, but the issue is still important because of the large exposed population. Shortcomings in studies carried out to date are discussed and recommendations for future studies are made, including:

- exposure assessment - accurate assessment of individual exposure through drinking, dermal and inhalation exposure is needed for range of DBPs. This will most likely involve detailed individual measurement for a subgroup of subjects combined with modelling for the remainder. Knowledge of water use patterns at home and at work will be needed, and the relationships between different classes of DBPs at different points in water distribution systems. Exposures also need to be assessed in the relevant time period during gestation for the outcomes under study.
- measurement of confounding / modifying factors - careful assessment needs to be made of factors which may also influence pregnancy outcomes including maternal age, history of past pregnancies, maternal smoking and alcohol consumption, exercise, nutrition, ethnicity, socioeconomic status, and occupational exposures.
- study design - some past studies have attempted to examine rare outcomes and different exposure levels with insufficient sample sizes. Appropriate study designs are needed to produce informative and meaningful results.

The authors conclude that further well designed epidemiological studies on reproductive outcomes and male fertility are needed, but also note that such studies will remain relatively crude until improved exposure assessment for DBPs is employed.

Gastroenteritis

A time series study of anti-diarrheal drug sales and tap-water quality.

Beaudeau P, Payment P, Bourderont D, Mansotte F, Boudhabay O, Laubies B, et al. *Int J Environ Health Res* (1999) **9** p293-311.

The objective of this study was to examine whether current water treatment is sufficient to

prevent all waterborne illness in the City of Le Havre, France. Records from two water treatment plants were compared with pharmacy sales records of anti-diarrheal and gastrointestinal medication to determine whether an association existed between levels of community gastroenteritis and changes in water quality parameters.

One water treatment plant (Radicatel) uses direct sand filtration prior to chlorination and also uses coagulation- setting when raw water turbidity exceeds 3 NTU (20% of time). The other plant (Saint-Laurent) uses only chlorination, and supplies consumers only when raw water turbidity is below 1.5NTU. The plants are continuously monitored for turbidity and free chlorine. Both plants extract water from a chalk aquifer, but the Radicatel source is frequently subject to the influence of surface water. The aquifer is subject to pollution from surface runoff and seepage.

An ecological time series approach was used for data collected between April 1993 and September 1996. Medication sales data from 3 pharmacies, residual chlorine and turbidity measurements were all analysed. Chlorine was detectable at the Radicatel site throughout the study period although barely detectable on 9 occasion. Failures of the chlorination process occurred on 13 occasions at the Saint-Laurent site with treated water containing no detectable chlorine.

A correlation was found between low or absent disinfection levels at the Saint-Laurent plant and an increase in medication sales. No such correlation was seen for the Radicatel plant. No correlation was seen between medication sales and changes in finished water turbidity from either plant, however an association was found between increases in raw water turbidity at the Radicatel plant and medication sales. The authors note that faecal indicator organisms (faecal coliforms and streptococci) were absent from treated water samples, but treated water turbidity occasionally reached relatively high values (4.9 NTU for Saint-Laurent and 3.0 NTU for Radicatel).

There was a delay of 3 to 8 days between chlorination failures at Saint-Laurent and increase in medication sales. A delay of 1 to 3 weeks was found between raw water turbidity increases at Radicatel and increased medication sales. The authors estimate that the overall rate of gastroenteritis from all sources was about 0.35 episodes /person /year, and that perhaps 0.02 episodes /person /year (about 10%) may be due to intermittent problems with drinking water quality.

Comment The observations reported in this paper support the hypothesis that some fraction of community gastroenteritis may be attributable to pathogens in treated drinking water. However the results rely heavily on medication sales data from the single pharmacy that recorded over the counter medication sales. The authors note that increasing computerisation of sales records will expand the available dataset for future studies. They also comment on recent recognition of the need for better operational practices for water treatment which would be expected to reduce risks - eg avoidance of chlorination failures and control of individual filter performance at treatment plants.



Helicobacter

Helicobacter pylori: characteristics, pathogenicity, detection methods and mode of transmission implicating foods and water.

Velazquez M, Feirtag JM. Internat J Food Microbiol (1999) **53**(2-3) p95-104.

This review article examines the phenotypic and genotypic characteristics of *Helicobacter pylori*, methods for in vitro culturing, evidence of its role in gastric pathogenicity, speculated modes of transmission and detection methods in food and water. *H. pylori* is associated with increased risks of chronic gastritis, peptic and duodenal ulcers, and adenocarcinoma and lymphoma of the stomach. It is estimated that about 10% of adults in developed nations harbour this bacterium, but occurrence rates are as high as 70 to 90% in developing countries.

The pathogen appears to be transmitted by the faecal-oral route but the importance of different modes of transmission (water, food, person to person etc) is uncertain. It has been difficult to isolate *H. pylori* from samples other than gastric tissues. *H. pylori* has the ability to survive in a viable but non-culturable coccoid (VNC) form which can not be cultured by traditional methods. Temperature has been found to be the main environmental factor associated with the development of VNC forms. VNC forms were found in water samples incubated at 4 and 15°C, but higher incubation temperatures (22 and 37°C) resulted in a loss of complete metabolic activity.

H. pylori is still viable and virulent in the VNC form, and can be detected by a number of methods including immunoseparation, molecular probes, autoradiography and ATP bioluminescence. The authors suggest that such methods should be used to assess the prevalence of the organism in water, food and environmental samples.



Legionella

Hospital characteristics associated with colonization of water systems by Legionella and risk of nosocomial Legionnaires' disease: A cohort study of 15 hospitals.

Kool JL, Bergmire-Sweat D, Butler JC, Brown EW, Peabody DJ, Massi DS, et al. Infect Control Hosp Epidemiol (1999) **20**(12) p798-805.

This paper describes an investigation of increasing reports of legionnaires' disease in hospitals in San Antonio, Texas. The sixteen largest acute-care hospitals in the cities of San Antonio, Austin and Temple were selected for the study. Data was collected from all known legionnaires' cases between January 1994 and January 1997, and microbiology laboratory databases of each hospital were reviewed for positive *Legionella* test results for the same period. From each hospital, water samples were collected from the bottom of all hot-water storage tanks and all water-heating tanks that supplied patient areas, or from hot-water return lines if tanks were not present. Water and swab samples were taken from shower heads and faucet aerators in patients

rooms that were furthest from the hot-water source. Information was also collected on hospital infection control measures, microbiology testing practices and water system maintenance .

A total of twelve cases of nosocomial (acquired in hospital) legionnaires' disease were found with eight of these occurring in 1996. A rise in cases occurred shortly after physicians started requesting *Legionella* urinary antigen tests. In San Antonio, *Legionella* was isolated from the water systems in 11 out of 12 hospitals. Cases of nosocomial legionellosis occurred in 5 hospitals. Those hospitals located in municipalities where water was treated with monochloramine as a residual disinfectant and those hospitals that had implemented control measures were *Legionella*-free. The 11 other hospitals had hot-water systems that were colonized with *Legionella* and were all supplied with drinking water that contained free chlorine as a residual disinfectant. Also in these infected hospitals the proportion of sites testing positive was inversely correlated with free residual chlorine concentration. Hot-water temperatures were too low in all hospitals to inhibit *Legionella* growth. The proportion of water-system sites testing positive for *Legionella* was a better predictor for risk of legionnaires' disease in hospital patients than was the concentration of *Legionella* bacteria.

Comment The observations in this study support those in a previous paper by the same first author (see Health Stream Issue 13, p17). Chloramine persists longer than chlorine in distribution systems, and may also penetrate biofilms within pipes more readily. In discussing the risks of nosocomial infections, the authors note that the presence of highly susceptible patients (especially transplant patients) is a major risk factor. Most hospitals maintain hot water temperatures below 110 degrees F but raising water temperature slightly (to 122 degrees F) can substantially reduce *Legionella* colonisation with minimal risk of scalding to patients.



Microsporidia

Waterborne outbreak of intestinal microsporidiosis in persons with and without human immunodeficiency virus infection.

Cotte L, Rabodonirina M, Chapuis F, Bailly F, Bissuel F, Raynal C, et al. J Infect Dis (1999) **180**(6) p2003-8.

This paper describes a retrospective review of parasitology test data in the region of Lyon, France from May 1993 to December 1996. A single reference laboratory receives faecal specimens from a population base of 1.5 million. Findings were linked with survey data for HIV infection collected by the French Ministry of Health. HIV-infected persons had data collected on age, gender, risk factors for HIV, weight, CD4 cell count and the presence of diarrhea at the time of stool analysis. Other people who submitted stool specimens had data available that included age, gender and confirmation of serologic status regarding HIV infection. Drinking water in Lyon comes from the Rhone River and is chlorinated and distributed into three subsystems.

A total of 5692 stool samples from 1453 patients were assessed for microsporidia. Positive stools were found from 338 patients, including 261 (77%) HIV-infected patients, 16 (5%) transplant patients and 61 (18%) others with normal immune systems.. An increase in the percentage of stools positive for microsporidia was seen in May 1995 and was related to an increase in new diagnoses. This increase continued until November 1995, and during this period more than 50% of stools tested positive. A total of 200 cases occurred during the outbreak. There was no increase in cases of other protozoan pathogens (*Cryptosporidium* or *Giardia*). Analysis of risk factors for infection showed a strong statistical association with residence in one of the 3 water distribution systems. Routine water testing for faecal indicator organisms showed no noticeable problems with water quality.

The authors conclude that in HIV-infected persons the disease microsporidiosis appears to be endemic (prevalence about 0.1%) and the severity related to immunologic status. In people not

infected with HIV the disease appears to be sporadic, with a prevalence of less than 1 in a million. Male homo/bisexuality was associated with microsporidiosis as was HIV infection, low CD4 cell counts and the presence diarrhea at time of analysis.



Mycobacteria

Prevalence of mycobacteria in a swimming pool environment.

Leoni E, Legnani P, Mucci MT, Pirani R. J Appl Microbiol (1999) **87**(5) p683-688.

This study was undertaken to assess the prevalence of non-tubercular mycobacteria in the swimming pool environment. Twelve public indoor swimming pools in the city of Bologna, Italy were examined. A chemical and microbiological examination was carried out on the water in each pool with 68 samples collected. Samples from each phase of treatment were taken including water leaving the pool, after filtration and after chlorination. Swabs were taken at four sites from each side of the pool edge, from the floor of each shower and from the changing-room benches, to measure microbiological contamination.

Non-tubercular mycobacteria were recovered from 88.2% of pool water samples with concentrations between 2 and 968 cfu/100ml. Most frequently isolated was *Mycobacterium gordonae*, being found in 73.5% of samples, next most frequent was *M. chelonae* isolated from 38.2% of samples, followed by *M. fortuitum* from 35.3% of samples.

Mycobacteria were found in 66.7% of samples of water entering the pool and 91.7% of samples of water leaving the pool. Mycobacteria were found in all samples from pool edges and shower floors but not from changing-room benches. *M. gordonae* was found in 80% of pool edge samples and 79.6% of shower floor samples. *M. chelonae* and *M. fortuitum* were also found frequently on pool edges and shower floors. Sporadic recoveries were made of *M. flavescens*, *M. phlei* and *M. terrae* from pool water, pool edge samples

and shower floor samples. *M. marinum* was recovered on two occasions from shower floors.

Filtration and chlorination only brought about a slight reduction in the mycobacteria count. Results showed that the swimming pools provided a suitable habitat for the survival and reproduction of mycobacteria and that their presence was enhanced by high average pool temperatures and concentrations of chlorine that were lower than the 1mg/L free chlorine necessary to control mycobacteria. Mycobacterial disease has rarely been associated with swimming pool environments, with the exception of *M. marinum* skin infections (swimming pool granuloma). However, given the widespread presence of these microorganisms throughout the pool environment and the direct contact pool users have through water and resulting aerosols, the possible health risks for people with weakened immune systems should be considered.



Norwalk-like-virus

Outbreak of viral gastroenteritis due to drinking water contaminated by Norwalk-like viruses.

Kukkula M, Maunula L, Silvennoinen E, von Bonsdorff CH. J Infect Dis (1999) **180**(6) p1771-1776.

In March 1998 an outbreak of gastroenteritis occurred in the Finnish municipality of Heinavesi. Heinavesi has a population of 4860 people and an area of 1318 km². About 2100 inhabitants live in the main village center which is supplied with municipal tap water from Lake Kermajarvi. Water treatment consists of sand filtration and chlorination. An increase in the number of patients with gastroenteritis attending the local health care centre was observed in March 1998 and in early April Norwalk-like virus (NLV) was found in patient's stool samples.

A retrospective epidemiological study was initiated to discover the source of infection and determine the incidence of gastroenteritis. A questionnaire was given to every home in the municipality and included questions about recent

symptoms of gastroenteritis, date and time of illness and illness among contact persons. Questions were also asked about eating history and consumption of municipal tap water. A total of 27 stool samples were examined from adults with acute gastroenteritis. Fifty three percent of the population answered the questionnaire.

It was estimated that between 1700-3100 cases of gastroenteritis occurred in the district in about 9 days, with all age groups equally represented. Symptoms were of short duration and only about 50 people sought medical attention. However about 800 working days were lost due to the illness, and total costs for the outbreak were estimated at US \$300,000.

Those who used municipal water had a 3.5 times higher risk of developing disease than those who used water from a private well, boiled water or bottled water (95% CI, 3.11-3.96). NLV genogroup II (GGII) was identified by use of RT-PCR and amplicon sequencing in samples taken from untreated water, treated water and tap water and from fifteen of the 27 patient stool samples. From patients samples, both NLV GGI and GGII were detected. Some stool samples were also tested for bacterial pathogens and *Cryptosporidium* and *Giardia*, but none were positive. 89 people reported two episodes of illness, and secondary person to person transmission is likely to have been responsible for a substantial number of cases.

The source of the contamination of Lake Kermajarvi is uncertain, although it is possible that a large foodborne NLV outbreak in the city of Kuopio (70km upstream of Heinavesi) which occurred four months earlier, may have caused the outbreak. Another possible source was a service station with restaurant which discharged treated sewage about 6 km upstream of Heinavesi. At the time of the outbreak the water was covered with ice and low temperatures may have prolonged survival of the virus.

A review of water treatment records showed that during the outbreak chlorine concentrations were much lower (0.07 to 0.03 mg/L) than the goal value of 0.8 mg/L and not adequate to destroy

NLVs. It is suggested that regular surveillance for viruses in drinking water should be considered in order to prevent waterborne viral epidemics.



Water Quality

Seasonal correlation of well contamination and septic tank distance.

Arnade LJ. Ground Water (1999) **37** p920-923.

In Palm Bay, Florida, the residents (approximately 40,000) rely on septic tanks for their sewage disposal and use wells as their primary source of drinking water. During July to September, the wet season, high levels of rain occur with mean precipitation greater than 63 cm. The result of these high levels of rain and the presence of porous sandy soils is high water tables and septic tank overflow. Septic tank leachate contaminates the groundwater as it can not percolate through the soil during the wet season and therefore poses a health risk to those drinking from local wells.

To determine the effects of season on fecal coliform and nutrient contamination of wells and to examine the effects of distance between wells and septic tanks, sixty residential wells in Palm Bay were tested for fecal coliforms, nitrates and phosphates. A well water questionnaire was distributed. Ground water samples were collected at various distances from septic tanks during the wet season and the dry season.

The results showed that samples collected during the wet season contained twice as many fecal coliforms and higher concentrations of nitrates and phosphates in comparison to samples collected during the dry season, with fecal coliform counts almost double in the wet season. A statistically significant correlation was found between increasing fecal coliform, nitrate and phosphates concentrations and decreasing distance between wells and septic tanks.

Variation of 66 elements in European bottled mineral waters.

Misund A, Frengstad B, Siewers U, Reimann C. Sci Total Environ (1999) **244** p21-41.

During 1997, 56 bottles of mineral waters were bought in randomly selected shops all over Europe and analysed for 66 elements. Median values for a number of elements were below detection: Ag, Er, Eu, Ga, Gd, Ho, In, PO₄, Pr, Sm, Sn, Tb, Tm, Yb. The highest median concentrations were found for Ca, SO₄, Na, Cl, Mg, K, Si, which were all above 1 mg/l.

Mineral waters with high total mineralisation came from Scandinavia, Russia and the Baltic States and Germany. Values of total mineralisation of water samples ranged from 19 to 6695 mg/l. Differences in concentration for single elements ranged from one to six orders of magnitude. Differences in composition were observed between regions due to geology of the area and to taste differences and local regulations. The type of bottle the water was sold in also influenced general water chemistry. It was found that waters stored in glass bottles had a much higher median Pb, U, Zr, Li, K and Na concentrations.

When results from the mineral waters tested were compared with currently valid action levels for drinking water, only 15 bottles out of 56 would pass all drinking water standards for inorganic constituents. For elements with known adverse health implications (As, Ba, Br, F, S and Ti) relatively few bottles exceeded action levels.

Such a large natural variation in concentration of elements seen in the mineral waters makes it apparent that little is known about the natural variation of elements in water. Action levels for drinking water are not necessarily set on a scientific or health related basis and the presumption is made that "natural" water is "clean" and does not show a large variation in element concentration. The results of this study suggest that it could be useful to analyse a wide range of elements and create a database on water chemistry for the whole of Europe. This could be used to create meaningful action levels for a small set of elements crucial for public health.

Comment The authors note that the EEC definition of "mineral water" relates to the protected nature of the source, with particular

emphasis on bacteriological quality. This concept presupposes that "pollution" is the main threat to water quality, and does not consider that "natural" constituents of water may be harmful. Increasing numbers of people are using bottled waters of various types as their principal drinking water source, and may be exposed to hazardous levels of some elements. The paper also highlights the anomalies resulting from regulations which are not applied equally to products used for the same purpose.

Abundance of clinical enteric bacterial pathogens in coastal waters and shellfish.

Yam WC, Chan CY, Bella SWH, Tam TY, Kueh C, Lee T. Water Research. (2000) 34(1) p51-56.

This study examined the prevalence of enteric bacterial pathogens in the environment by analysing bacterial isolates from diarrhoeal patients, coastal waters and shellfish from Hong Kong Island. From January to December 1993, stool or rectal swabs were collected from patients with diarrhoea at Queen Mary Hospital. During 1992 and 1993, 24 water samples were collected from sites where there was known sewage pollution. During this time 12 shellfish samples (oysters, clams and mussels) were purchased from wet-markets at different localities.

A total of 1211 bacterial isolates from clinical samples were identified. Of these, Salmonellae were the most frequently identified (66%), followed by *Campylobacter* spp (13%) and *Shigella* spp (6%). From coastal waters 344 bacterial isolates were identified, of these 62% were Vibrios, 18% were Salmonellae and 18% were Aeromonas. Of the 114 shellfish isolates, 89% were Vibrios and 10% were Salmonellae.

Serotyping of the 870 *Salmonella* isolates showed that those occurring in water were different to those in hospital patients. Vibrio species isolated from environmental samples did not include *V. cholerae* 01 nor *V. cholerae* 0139. It was concluded that bacterial pathogens present in coastal waters and shellfish in Hong Kong were not similar to those in hospital patients with severe gastroenteritis.



List of Articles

Arsenic

Biological monitoring of occupational exposure to inorganic arsenic.

Apostoli P, Bartoli D, Alessio L, Buchet JP. Occupational & Environmental Medicine. (1999) **56**(12) p825-832.

Disinfection By-products

A new look at disinfection by-products in drinking water.

Marhaba TF. Water-Engineering & Management (2000) **147**(1) p30-34.

Gastroenteritis

Drinking water turbidity and gastrointestinal illness in the elderly of Philadelphia. Schwartz, J., R. Levin, et al. (2000). J Epidemiol Comm Health **54** p45-51.

Comparison of six dose-response models for use with food-borne pathogens.

Holcomb, D. L., M. A. Smith, et al. (1999). Risk Analysis **19**(6): 1091-1100.

Water Quality

The microbiological quality of ice used to cool drinks and ready-to-eat food from retail and catering premises in the United Kingdom.

Nichols, G., I. Gillespie, et al. (2000). Journal of Food Protection **63**(1): 78-82.

Impacts of the reduction of nutrient levels on bacterial water quality in distribution systems.

Volk, C. J. and M. W. LeChevallier (1999). Applied & Environmental Microbiology **65**(11): 4957-4966.

Use of total coliform test for watershed monitoring with respect to atypicals.

Brion, G. M. and H. Z. H. Mao (2000). Journal of Environmental Engineering-ASCE **126**(2): 175-181.

Detection of odour and health risk perception of drinking water.

Jardine, C. G., N. Gibson, et al. (1999). Water Science & Technology **40**(6): 91-98.

A pilot study of bacteriological population changes through potable water treatment and distribution.

Norton, C. D. and M. W. LeChevallier (2000). Appl Environ Microbiol **66**(1): 268-76.

Biological warfare agents as threats to potable water.

Burrows, W. D. and S. E. Renner (1999). Environmental Health Perspectives **107**(12): 975-984.

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 *Public Health Risk Assessment* of the CRC for Water Quality and Treatment. Health Stream provides information on Program 1 research activities, updates on the recent literature and topical issues in health research which are of particular relevance to the water industry.

The CRC for Water Quality and Treatment also produces the quarterly newsletter **Water Quality News** featuring current affairs, highlights from all 4 research programs of the CRCWQT, and information about other CRCWQT activities.

Both newsletters are available free of charge to the water industry, public health professionals and others with an interest in water quality issues.

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

Pam Lightbody
Epidemiology and Preventive Medicine
Monash Medical School, Alfred Hospital
Prahran VIC 3181, AUSTRALIA

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