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New US Arsenic Rule

The USEPA has proposed lowering the Maximum Contaminant Level for arsenic in drinking water from 50 ppb to 5 ppb (ppb=micrograms/litre). The proposal follows EPA consideration of a 1999 report from the National Research Council reviewing epidemiological studies on the health effects of arsenic and data on possible carcinogenic mechanisms⁽¹⁾. The report concluded that the current US regulatory level of 50 ppb did not provide sufficient protection of public health. However, it did not specify a concentration which provided a safe level for long term exposure. The EPA has opened the proposed MCL for comment, prior to making a final decision on the matter and promulgating the new regulatory limit.

The current 50 ppb level was set on the basis of estimated risks of skin cancer, however some recent data suggests that long term consumption of water at this level may be associated with increased risks of internal cancers such as lung and bladder cancer. There are a number of uncertainties in the assumptions used in this risk assessment, however the lifetime risk for bladder cancer may perhaps be as high as 1 in 1,000 for people consuming water at 50ppb. The EPA target value is 1 in 10,000 or less.

The risk estimate of 1 in 1,000 for bladder cancer at the current MCL of 50 ppb is based on linear extrapolation of observations from human exposure to levels of several hundred ppb. The National Research Council report noted that for all modes of arsenic carcinogenicity proposed to date, a non-linear or threshold dose-response relationship would be expected. Therefore in adopting a linear dose-response relationship, the EPA made a policy decision to use a more conservative assumption which produces higher risk estimates for low level exposures than a non-linear model.

The new MCL will apply to all community water systems and non-community non-transient (NTNC) water systems (those which serve 25 of the same people for 6 or more months of the year). NTNC systems (such as schools, nursing homes, service stations) have not previously been subject to arsenic regulations. As few surface water supplies have significant arsenic contamination problems, the change will impact mainly on systems drawing their supplies from groundwater. Large systems will have 3 years to implement the new MCL after it is finalised, while small systems (serving less than 10,000 people) will have 5 years to achieve compliance.

After evaluating current analytical methods the EPA determined that the practical quantitation limit for measurement of arsenic in water supplies was 3 ppm. This was also found to be the lowest level achievable in finished drinking water drawn from arsenic contaminated sources and treated using currently available technologies. An analysis was then carried out to determine the likely impact of adopting a new arsenic MCL for drinking water at levels of 3, 5, 10 or 20 ppb.

The analysis considered the following aspects:

- available data on the occurrence of arsenic in ground and surface water sources in the US
- the number of people supplied by water sources in each category
- co-occurrence of other water contaminants that may affect treatment options and costs
- the sensitivity, reliability and cost of arsenic analytical methods
- monitoring and reporting requirements
- best available treatment technologies
- costs for water systems of different sizes, and costs per household served
- predicted health benefits including medical costs avoided, monetary value of statistical lives saved and nonfatal risks avoided
- risk management decisions
- effect on state regulation programs
- health risk reduction and cost analysis
- administrative requirements

The estimated annual health benefits in terms of fatal and non-fatal bladder cancer cases⁽²⁾ avoided and the equivalent monetary value (based on the

Value of a Statistical Life method ⁽³⁾) for community water systems were as follows:

Health Benefits – Community Water Systems

Arsenic level	Fatal bladder cancers avoided	Non-fatal bladder cancers avoided	Bladder cancer health benefits \$ millions
3	6 - 14	16 - 39	43.6 - 104.2
5	4 - 12	12 - 33	31.7 - 89.9
10	2 - 7	7 - 19	17.9 - 52.1
20	1 - 4	3 - 11	7.9 - 29.8

For NTNC systems, the degree of exposure and the number of people at risk are much lower, therefore the estimated health benefits are smaller:

Health Benefits – NTNC Water Systems

Arsenic level	Total bladder cancers avoided	Bladder cancer health benefits \$ millions
3	0.132 - 0.294	0.601 - 2.717
5	0.104 - 0.229	0.481 - 2.116
10	0.064 - 0.147	0.296 - 1.359
20	0.039 - 0.088	0.180 - 0.814

These estimates do not consider possible health benefits from reduction in the risks of other cancers or reduction in non-cancer adverse health effects. There is some evidence that exposure to arsenic may also increase lung cancer risks, although this is less well documented than the effects on bladder cancer. Rates of other internal cancers (eg liver, kidney, prostate) may also be increased. If the potential benefits from reduction in lung cancer risks are also included, the monetary value of health benefits may be about 4-fold higher than these estimates. Reductions in non-cancer risks would also increase the value of health benefits, although by a lesser degree than reductions in cancer risks.

In order to meet a lower MCL, a number of water supply systems will need to implement new water treatment facilities or improve the operation of existing facilities. There will also be additional costs for monitoring arsenic levels, and administration by state authorities. Estimates of

annualised national compliance costs at discount rates of 3% or 7% were as follows:

Annualised National Compliance Costs

Arsenic level	Total (\$ millions)	
	3%	7% discount rate
3	644.6	753.2
5	378.9	442.2
10	164.9	192.4
20	63.2	73.7

The Benefit /Cost analysis demonstrates that for all scenarios under consideration, the economic costs of lowering the MCL for arsenic are greater than the economic value of the potential health benefits. At a 7% discount rate the Benefit /Cost ratio for an MCL of 3 ppb ranges from 0.06 to 0.14 (ie between 6 cents and 14 cents of health benefit for each dollar spent on compliance). For an assumed MCL of 5 ppb the Benefit /Cost ratio range is 0.07 to 0.20, for an MCL of 10 ppb the Benefit /Cost ratio range is 0.09 to 0.27, and for an MCL of 20 ppb the Benefit /Cost ratio range is 0.11 to 0.42. These ratios are based only on consideration of bladder cancer risks. If other types of cancer and non-cancer benefits are considered, the potential health benefits would be about 4-fold higher.

After considering the potential costs and benefits of different MCLs, the EPA chose 5 ppb as the MCL for the proposed new rule. Due to the adoption of the linear low level risk extrapolation model (ie assuming there is no threshold and therefore any level of arsenic entails some degree of cancer risk), the Maximum Contaminant Level Goal (a non-enforceable level) is zero. In setting the proposed MCL at 5 ppb rather than 3 ppb (the lowest feasible level achievable by water treatment) the EPA has exercised its discretionary power to select an MCL which it deems “maximises health risk reduction at a level where costs and benefits are balanced”.

The EPA estimates that about 6,600 community water systems serving a total of about 22.5 million people would be affected by the proposed MCL of 5 ppb. The majority of these are small systems each serving less than 10,000 people. The new regulations would impact most heavily

in Southwestern states, with some areas of the West, Midwest and New England also affected. According to EPA estimates, the additional costs for individual households will range from an average of \$28 per year for large systems to \$85 per year for small systems.

The American Water Works Association Research Foundation commissioned an independent assessment of the compliance costs which found that the actual costs of implementation of a lower MCL are likely to be higher than the EPA estimates. This review found that water treatment costs were likely to be higher and that the EPA had not adequately considered a number of factors which may have a substantial impact on costs:

- The MCL will mainly affect groundwater systems, many of which have no current water treatment or minimal treatment in place. As a consequence many utilities may need to acquire land to accommodate larger treatment plant facilities, and may lack sufficient numbers of staff who are experienced in plant operation. Such utilities may also lack facilities and experience for chemical storage and handling.
- The EPA analysis has assumed that waste from arsenic removal will not be regarded as hazardous material, and may be disposed readily to sewers or streams. If this is not the case, additional facilities will be needed to treat arsenic-containing waste before disposal. Waste disposal considerations may also impact on the choice of water treatment technologies by some utilities.
- The degree of water loss from some treatment technologies may preclude their use by some utilities and force other more expensive methods to be adopted.
- The impact of multiple entry points to distribution systems has not been adequately addressed. Many groundwater systems draw water from multiple wells, and separate treatment facilities will be needed at each source which exceeds the MCL. This could increase costs for these systems by as much as 150% to 250% over a single entry point system of equivalent size.

Overall, the AWWA estimates of compliance costs for the 5 ppb MCL are up to 4-fold higher than the EPA figures. Some estimates have put the capital cost as high as \$14 billion, with annual costs of \$1.4 billion.

The NRC report noted there is considerable controversy over the interpretation of scientific evidence on the health effects of chronic low level arsenic exposure. Epidemiological data come mainly from populations with exposures in the range of several hundred ppb in drinking water, who also had substantial arsenic exposure from food and may have suffered from nutritional deficiencies. In the light of these uncertainties, some members of the NRC panel have stated the view that a standard below 10 ppb (the current World Health Organisation guideline value) is not scientifically supportable on present evidence.

The Arsenic Rule is due to be finalised and issued by 1 January 2001, despite the fact that the public release of the proposed MCL on 22 June was almost 6 months late. Environmental advocacy group the Natural Resources Defense Council has applied to the US Court for the District of Columbia to order the EPA to comply with the January release date, however this has been opposed by the AWWA on the grounds that Congress intended to allow one full year between the proposal and the final rule. The AWWA argues that full discussion and review is essential due the complex and costly nature of the proposal. According to some estimates, the new Arsenic Rule may be the most expensive drinking water regulation ever introduced in the US, with compliance costs higher than the combined costs of all regulations introduced before 1995.

(1) Arsenic in Drinking Water (1999). National Academy Press, Washington. ISBN 0-309-06333-7.

(2) About 23,600 cases of bladder cancer are diagnosed in the US each year. Smoking (the single greatest risk factor) accounts for 41% of cases.

(3) Value of a Statistical Life - the VSL refers to the value of small reductions in risk across a population, not to the value of an individual identifiable life. For example, if 100,000 people were willing to pay \$20 each for a reduction in fatality risk of 1/100,000, then the value of the theoretical single life saved across the population would be \$2 million. The current EPA VSL is \$6.06 million.

UK *Cryptosporidium* Monitoring

The UK Drinking Water Inspectorate has released the results of the first few months of *Cryptosporidium* monitoring under legislation introduced in June 1999⁽¹⁾. The legislation requires continuous daily sampling from treatment works with significant risk of having *Cryptosporidium* oocysts in drinking water. Each sample comprises a minimum of 1,000 litres of water sampled through a compressed foam filter at a rate of about 40 litres per hour over 23 hours. Detection of oocysts exceeding an average concentration of 1 per 10 litres of water constitutes a criminal offence under the regulations. The regulations do not distinguish between intact and empty oocysts, nor take account of any measure of viability /infectivity.

Assessment of nearly 1,500 sites in England and Wales resulted in the classification of 335 sites as being at significant risk, and thus subject to the regulations. Water companies have indicated that about 80 of these sites will be either temporarily or permanently abandoned due to the disproportionate costs of bringing them into compliance with the requirements. Installation of monitoring apparatus at the highest risk sites commenced in late 1999, and monitoring at the first 68 sites began in April this year. By the end of August, 190 sites had commenced monitoring.

The first results of the monitoring program were announced in June. Of 6,190 samples processed, 627 (10%) were positive for *Cryptosporidium* oocysts. A single sample was found to exceed the regulatory level, with an average concentration of 1.4 oocysts per 10 litres detected. The DWI noted that this result coincided with an increase in water turbidity, although there is no information on whether such turbidity increases were also seen in the absence of oocysts.

Cost figures have not been released, however according to a Discussion Paper released by the DWI prior to implementation of the regulations, costs were estimated at £8 million per year based on the assumption that 121 plants would require monitoring. With the revised figure of 335 sites requiring monitoring, and assuming that 80 of

these will be abandoned, the annual cost of the monitoring program for the remaining 255 sites is likely to be in the order of £17 million. It is expected that major upgrades (installation of membrane filtration capable of removing particles down to 1 micron in size) will be undertaken at about 100 of the 255 sites, thus exempting them from the monitoring requirements.

Breaches of the regulations constitute a criminal offence punishable by a maximum fine of £5,000 in Magistrates' Courts, or unlimited fine in Crown Courts. The regulations have yet to be legally tested but it is believed that all cases would initially go to Magistrates' Courts, and the individual Magistrate would have the discretion to refer the matter to the Crown Court taking into account the views of the Prosecution and Defence counsels and the complexity of the case.

The Drinking Water Inspectorate considers the regulations to be "probably one of the most significant advances in public health protection made in water supply in the last decade".

Comment By any conventional measure of public health programs, the cost of implementing these regulations is disproportionate to the potential benefits. It has been estimated that about 32,500 cases of cryptosporidiosis occur each year in England and Wales (2). If it assumed that 50% of these may be waterborne (absolute worst case) and all such cases are prevented by the regulations (extremely optimistic), then each case prevented would cost more than £1,000. In contrast, each year of life gained as a result of breast screening mammography costs £3,000, and for renal dialysis or coronary-bypass surgery the costs are £25,000 and £5,000 respectively. These are three life-saving interventions, whereas cryptosporidiosis is an illness of about 5 days duration and life-threatening only in a small minority of the population with profound immunodeficiency or serious pre-existing illness.

(1) See Health Steam Issues 11 and 15 for further information on the UK Regulations.

(2) Wheeler JG et al (1999) Study of infectious intestinal disease in England: rates in the community, presenting to general practice, and reported to national surveillance. *British Medical J* (1999) **318**: 1046-50.

Walkerton *E. coli* Outbreak

The Walkerton outbreak was declared over on 13 July, eight weeks after the town's water supply was found to be contaminated by *E. coli* O157:H7 bacteria⁽¹⁾. Fears of a further outbreak were raised in mid-August by newspaper reports that several new *E. coli* O157:H7 infections had been diagnosed in young children. However health officials moved quickly to reassure the public that these newly diagnosed infections were cases dating from the original outbreak who had suffered intermittent symptoms and had only recently been brought to medical attention.

As of 17 August, laboratory tests on faecal specimens had confirmed 198 cases of *E. coli* O157:H7 infection, including 26 people who developed haemolytic uremic syndrome (HUS), a serious complication associated with kidney damage. A further 119 people were diagnosed with *Campylobacter* infection. Tests for other microorganisms are continuing. At least 68 people were admitted to hospital, about 1,000 attended hospital emergency departments, and 1460 people who suffered gastroenteritis symptoms were interviewed by the local Public Health Unit during the investigation.

The finding of infections from more than one microorganism is not unexpected, as faecal contamination from either human or animal sources is likely to contain a mixture of pathogens. The number of laboratory confirmed cases is relatively low compared to the number of people who became ill (estimated at around 2,000), since even in this highly publicised outbreak only people with severe symptoms submitted faecal specimens for analysis.

A total of 21 deaths in Walkerton and nearby areas during the outbreak period were investigated by Ontario's Chief Coroner. The Coroner concluded that four deaths were directly attributable to the water contamination and that *E. coli* infection played a contributory role in two additional deaths. Fourteen deaths were found to be unrelated to the outbreak and one had insufficient information available to make a determination.

Investigations into the source of the water contamination continue to focus on faecal contamination from livestock. Several local cattle herds have been found to carry the *E. coli* O157:H7 strain, including a herd of 95 beef cattle on a farm only half a kilometre from one of the three wells in use at the time of the outbreak. This well (No.5) is only 15 metres deep, and is considered the most vulnerable to contamination. It is also located in closer proximity to livestock than the other two wells (No.6 and 7). However the chlorinators on wells No.5 and 6 are believed to have been operating satisfactorily prior to the outbreak, while that on well No.7 was unreliable.

Well No. 5 was closed when the outbreak was detected in May, and Well No.7 was reportedly shut down on 1 September following detection of high coliform counts. It has been reported that all three wells maybe subject to intermittent contamination from surface waters, and there has been speculation that contamination may even have reached the underground aquifer.

The Ontario provincial government announced a no-fault compensation package for people affected by the outbreak in early June, and by mid-August emergency payouts for expenses totalling about \$400,000 had been made. The compensation package also includes payment for illness or death of family members with the amount to be determined by a mediator. No claims of this nature had been lodged by 17 August although over 550 enquiries had been made. People accepting a compensation payment under the government scheme are required to give up their right to sue the province for damages.

A civil class-action suit claiming \$300 million in damages has been lodged by lawyers representing a number Walkerton residents and businesses. The suit names five defendants - the Municipality of Brockton, the Walkerton Public Utilities Commission and its Manager, the Bruce-Grey-Owen Sound Health Unit, and the Ontario government. A decision on whether the suit meets legal criteria for class action and is thus eligible to proceed to trial is expected from the Ontario Superior Court by November.

Walkerton schools are expected to reopen in September, with the costs for sending local children to schools outside the area over the last few months estimated at over \$300,000. Schools have installed new storage tanks, piping and taps at a cost of \$600,000. Provision is being made for supplies of bottled drinking water for students and staff, and primary (elementary) schools will even use imported water for flushing toilets.

The boil water notice issued on 21 May for Walkerton still remained in force at the time of going to press (12 September). Contractors have completed an extensive decontamination program including hyperchlorination and flushing of pipes in all individual homes, schools and businesses, as well as treating and flushing mains. Showerheads and aerators have been replaced, and fire hydrants and water valves cleaned. The Ministry of the Environment has ordered the replacement of 3.5 kilometres of old cast iron water mains after it was decided that build up of iron oxide scale prevented effective cleaning of the system.

The Walkerton Inquiry The Ontario Government established a Commission of Inquiry to investigate the Walkerton outbreak on June 12. The Inquiry is headed by Justice Dennis O'Connor, a senior judge from the Ontario Court of Appeals ⁽²⁾. The Commission has a mandate to inquire into:

- the circumstances which caused hundreds of people to become ill and as many as 11 people to die at a time when *E. coli* bacteria were found in the Walkerton water supply;
- the cause of these events, including the effect, if any, of government policies, procedures and practices, and;
- any other relevant matters the Commission considers necessary to ensure the safety of Ontario's drinking water.

The Commission has been specifically excluded from expressing any conclusion or recommendation about the civil or criminal responsibility of any person or organisation in the tragedy. It must also avoid conflict with any criminal investigations and proceedings which may arise in relation to the outbreak. The

Opposition political party has welcomed the broad mandate of the Inquiry but expressed concern over the lack of an overall time limit or any requirement to deliver interim reports on urgent matters within a specified time frame.

The Inquiry will be conducted in two parts which will run concurrently. Part I will focus on the events in Walkerton, while Part II will focus on matters relevant to ensure the safety of drinking water in the province. As a prelude to the Inquiry, Justice O'Connor visited Walkerton for a series of public consultations and private meetings with residents over several days during August. These informal meetings were closed to the media and do not constitute legal evidence.

The formal Inquiry will commence in October but will be preceded by the hearing of applications for "standing" from more than 80 groups and 200 individuals. Applications for funding assistance from parties who would otherwise be unable to participate will be held at the same time. Under Canadian law only those granted legal "standing" are permitted to take part in the proceedings of Public Inquiries and to make submissions. In this instance, standing will be granted to those directly and substantially affected by the events in Walkerton in May and June of this year, and to those who represent clearly ascertainable interests and perspectives that are deemed essential to the mandate of the Inquiry. The Commissioner has the power to determine in which section(s) of the Inquiry each party may participate.

The Inquiry will be assisted by a Research Advisory Panel which is charged with providing the best available scientific and practical advice for the Inquiry's recommendations. The seven members of the panel will assist the Inquiry to identify a series of key topics on which expert review papers will be commissioned. The draft papers will be open to public comment and further discussions with relevant experts, and will provide the basis for policy advice to the Inquiry.

The outbreak and its aftermath continue to attract prominent media coverage in Canada, and associated issues of drinking water safety and regulation are also in the public eye. Shortly after

the outbreak, the Ontario Ministry of the Environment ordered inspections of the provinces's 630 drinking water treatment plants, starting with those with a history of problems. Of the first 240 plants inspected, 152 were found to have deficiencies in at least one area including sampling frequency, chlorination, filtration, operator certification and backup systems. In 72 cases the problems were sufficiently serious to warrant immediate orders for remedial action.

The provincial government recently announced new regulations which will set minimum requirements for sampling and testing water supplies by accredited laboratories, immediate reporting of adverse test results to the Ministry of the Environment, posting of public notices regarding water contamination, and production of quarterly reports available to the public. It is also expected that about 30 towns with unfiltered supplies will be required to build filtration plants. Provincial funding of \$240 million will be provided over the next two years to assist municipalities to upgrade plants, with matching funding expected from the Canadian Federal government. However the regulations do not cover some small supplies, and critics have charged that they do nothing to provide better protection of water supplies from contamination.

The Walkerton tragedy has also heightened public concern over *E. coli* infections, with a number of food-borne and animal related outbreaks in Canada and the United States receiving increased publicity. Several large recalls of ground beef have occurred in the past few months following the detection of *E. coli* contamination in some batches. Canadian scientists are currently testing a vaccine in cattle that may eliminate the O157:H7 strain of *E. coli*, and thus reduce the contamination risk. Preliminary studies in mice are said to have been encouraging, but the vaccine's effect in cattle and its commercial viability have yet to be established.

(1) See Health Stream Issue 18 for a report on the Walkerton outbreak.

(2) The web page of the Inquiry can be found at: www.walkertoninquiry.com



OECD Expert Working Group

The OECD has formed an Expert Working Group to examine Approaches for Establishing Links between Drinking Water and Infectious Disease. Forty-two experts from 13 countries attended the first meeting of the group in Basingstoke UK from 9-11 July. The meeting was hosted by the Drinking Water Inspectorate, the body responsible for monitoring the compliance of water companies in England and Wales with the British Water Quality Regulations.

The meeting was organised into five sessions:

- Surveillance of Waterborne Disease
- Outbreak Investigation
- Use of Water Quality, Treatment and Distribution Data to Assess Human Health Risk
- Epidemiological Approaches to Assessing Endemic Waterborne Disease Burden
- International Policy Considerations

The experts discussed a range of new approaches to enhance current methods for surveillance and outbreak investigation, in particular the development of realtime measurements and/or predictive models. Better utilisation of existing water quality data by the public health community was also seen as a priority. The group agreed that the issue of endemic waterborne disease requires further careful investigation to determine the magnitude of its impact on community health in both the developed and developing world.

Following the workshop, the OECD will produce a policy guidance document which is intended to reach a wide variety of audiences, including scientists, health economists, government /industry representatives and the wider general public. The document will set out international guidance on best practice on epidemiological and microbiological approaches to establishing links between infectious disease and drinking water.



Australian Drinking Water Guidelines Rolling Revision

The NHMRC and ARMCANZ have released two revised Fact Sheets and published a Public Consultation Document on proposed revisions to the Australian Drinking Water Guidelines.

The revised Fact Sheets for *Cryptosporidium* (Fact Sheet 14) and *Giardia* (Fact Sheet 15) have been incorporated into the downloadable version of the ADWG on the NHMRC website:

<http://www.nhmrc.health.gov.au/publicat/synopses/eh19syn.htm>

The Public Consultation Document containing the proposed revisions can be downloaded from the NHMRC website: <http://www.nhmrc.health.gov.au/advice/contents.htm>

The revisions comprise the following material:

Chapter 4 - Radiological Quality of Drinking Water

Summary of Guidelines (Radiological Quality)

Fact Sheet 3 - Thermotolerant Coliforms and *Escherichia coli*

Fact Sheet 4 – Coliforms

Fact Sheet 8a - *Burkholderia Pseudomonas*

Fact Sheet 17a – Microcystins

Fact Sheet 17b – Nodularin

Fact Sheet 17c – Saxitoxins

Fact Sheet 17d – Cylindrospermopsin

Fact Sheet 31 - Radium-226 and Radium-228

Fact Sheet 33 – Uranium

Fact Sheet 34 - other Beta and Gamma-emitting Radioisotopes

Fact Sheet 35 – Aluminium

Fact Sheet 42 – Boron

Fact Sheet 49 – Copper

Fact Sheet 59 – Monochloramine

Fact Sheet 103 – Atrazine

Comments on the proposed revisions should be submitted to the NHMRC by 13 November 2000.

News Items

"Crystals" can kill *Cryptosporidium*

Australian scientists have reportedly discovered a "naturally occurring crystalline material" that severely disrupts the surface structure of *Cryptosporidium* oocysts. The discovery came during studies of the surface chemistry of oocysts and their behaviour during a range of different water treatment processes. The researchers at the Australian National University found that the strongly negatively charged surface of the oocyst was composed of a series of plate-like segments. While testing a number of materials to see which would most effectively adsorb oocysts, they found a substance which adhered so strongly that it cracked open the oocysts. Binding of the substance to the oocysts is apparently irreversible, and may be sufficient to kill them or make them susceptible to chlorine levels which are ineffective against intact oocysts. Preliminary results were reported in August at the International Association of Colloid and Interface Scientists conference in the UK, but little detail is available on the discovery as a patent application is pending.

Wallis Lakes Appeal Case

The NSW state government and one of Australia's largest oyster growing companies have lost an appeal to the Australian Federal Court over the 1997 Wallis Lakes Hepatitis outbreak. One person died and more than 440 became ill with Hepatitis A after eating oysters from waters contaminated with human waste. In 1999, the Court found the NSW State Government, Great Lakes Council and Graham Barclay Oysters Pty Ltd were equally culpable, and awarded \$30,000 to one of the victims in a test case.

In a recent appeal against this judgement, the Court upheld the ruling against the state government and the oyster grower, but ruled that the Great Lakes Council could not be held responsible as it was not "fair, just or reasonable" to impose a duty of care on the Council in this situation. The compensation figure awarded to the plaintiff was reduced to \$27,000. More than 280 additional claims from other victims of the outbreak are pending in two other court actions.

Leaks threaten reservoir plan

The UK Environment Agency has warned Thames Water that it may block a new reservoir planned by the company. Thames Water wants to build the new 2 mile x 1.5 mile reservoir to cater for anticipated demand from more than a million new homes expected to be built in the southeast of England in the next 16 years. The Environment Agency has criticised the water company for failing to put enough effort into reducing leaks from its supply system, and said a better performance must be achieved before it would consider a new reservoir. The agency has no direct authority to stop the development of the reservoir, but can refuse to issue the necessary extraction licenses which govern the abstraction and return of water to the river.

Sydney pollution lasts 7 months

Researchers modelling the movement of tides in Sydney Harbour have estimated that the half-life of pollution in the 500 billion litre water body is 225 days or longer. Although no significant barrier to tidal flow exists at the 3 km wide harbour mouth, the geography of the drowned river valley creates numerous eddies and obstructions which retard mixing of the water, particularly in the upper reaches of the harbour.

Disinfection "Pen" For Water Treatment

Researchers at the University of North Carolina have developed a compact water disinfection unit resembling a large writing pen. The "MIOX Disinfection Pen" was designed for use by military personnel and disaster relief workers in situations where safe water supplies are unavailable. The device, which weighs 4 ounces (about 113g) and is 7 inches (180mm) long, contains battery powered electrodes and salt tablets.

When drinking water is required, the user adds a small volume of water to the pen to dissolve the salt tablets, then switches on the battery power. The electrical current inside the device generates oxidising chemicals from the salt within 30 seconds, and the entire solution is then mixed into a quart bottle of water to be treated (about 1 litre). In laboratory tests, a treatment time of 10 minutes produced at least 99.99% reduction in the

numbers of common pathogenic viruses and bacteria. A smaller, less costly version of the pen is being developed for the outdoor recreation market.

UK Fluoride Regulation

The British Department of Health has signalled it will soon change legislation to give local council legal powers to compel water companies to fluoridate water supplies. The decision was made following a new report by the University of York which reviewed evidence on the benefits and adverse effects of fluoride on health.

USEPA To Change DBP Monitoring

The USEPA plans to change the way disinfection byproducts in water distribution systems are measured in order to provide tighter controls over levels of major DBP classes. Present regulations require quarterly measurement at 4 points which represent average DBP levels for the system. Considerable discretion is allowed on the timing of samples, so that two subsequent "quarterly" measurements can be almost 6 months apart.

The revised regulations are likely to require one sample at a representative average point, one at a point with high levels of haloacetic acids (HAAs), and two at points with high levels of trihalomethane (THMs). Requirements for the timing of samples will also be more restrictive. While the current limits of 80 microgram/litre for total THMs and 60 microgram/litre for HAAs will be retained under the new "Locational Running Annual Average" scheme, it is expected that the changes to sample location will effectively reduce allowable levels of THMs by 16% and HAAs by 25%. The changes will be incorporated into the Stage 2 Disinfectants/ Disinfection By-products Rule which is due to be proposed in early 2001.

Cryptosporidium Outbreaks

Northern Ireland UK A boil water notice has been issued to more than 60,000 people in townships and suburbs on the southern outskirts of Belfast due to a suspected waterborne cryptosporidiosis outbreak. About 70 laboratory confirmed cases have been diagnosed. Investigations centre on a possible fracture in the 110 year old Lagmore conduit. The conduit is in

the process of being replaced, and the Water Service is working to bypass the affected section with new piping, however this may take up to 2 weeks.

Ohio USA About 500 people are believed to have become ill with cryptosporidiosis and 115 cases have been laboratory confirmed over a 4 county area. Swimming pools were initially suspected as the source of infection, but investigations into other possible sources including drinking water are continuing.

Florida USA Hundreds of children may have been affected in a cryptosporidiosis outbreak believed to be associated with a fountain and children's play pool in Sarasota Island Park. Only 5 cases were laboratory confirmed, and the water was not tested for oocysts, however faecal indicators were found. Water in the 4,000 gallon reservoir of the fountain is now being changed daily instead of weekly, and chlorination levels have been increased.

China claims oldest W.C.

Archeological excavations in central China have revealed what may be the oldest water closet ever discovered. The lavatory was discovered in a royal tomb of the Western Han dynasty (206BC to AD24), and according to Chinese government sources is of sophisticated design. However, one of the archeologists who made the discovery has reportedly said he believes the drainage system may have been designed to prevent flooding of the tomb by rain, rather than to flush away waste.

Electrolysed water improves food safety

A system for producing electrolysed water for killing microorganisms while washing fruit and vegetables is being trialed by a US fast-food chain. The system was developed as part of a 3 year ongoing research study funded by the US Food and Drug administration. It consists of a tank holding saline water, through which an electric current is passed, producing a stream of acidic water. The treated water has reportedly been shown to be effective in killing a range of food poisoning bacteria including *E. coli* O157:H7, *Salmonella* and *Listeria*, but does not affect the taste or appearance of the food.

USEPA Avoids Block On Pollution Law

The US EPA is under criticism for issuing new laws on water pollution only hours before President Clinton was due to sign a bill that would block them. The laws (known as the Total Maximum Daily Load Rule) govern a range of pollutants entering water bodies, and will require the development of local programs to assess and manage both point and non-point sources in individual watersheds.

Many state authorities have complained they do not have the resources to implement such laws, and the agricultural community has disputed the EPA's authority to regulate non-point sources. Members of Congress opposed to the measures had attached an amendment blocking the new laws to an unrelated military construction bill. However the EPA published the new laws in the Federal Register only a few hours before the bill was due to be signed.

From the Literature

Aluminium

Relation between aluminum concentrations in drinking water and Alzheimer's disease: An 8-year follow-up study.

Rondeau V, Commenges D, Jacqmin-Gadda H, Dartigues JF. *Am J Epidemiol* (2000) **152**(1) p59-66.

The relationship between aluminium and silica in drinking water and the risk of dementia and Alzheimer's disease was examined in this study. A large prospective cohort of 3,777 subjects aged 65 years or older at baseline was used. All subjects were living at home in one of 75 rural or urban parishes in the areas of Gironde or Dordogne in southwestern France from 1988-1989. For baseline screening, subjects underwent a 1-hour interview at home with a specially trained psychologist. Subjects were reevaluated at 1, 3, 5 and 8 years after the initial visit in Gironde and 3, 5 and 8 years later in Dordogne to diagnose incident cases of dementia.

The water distribution network was divided up into drinking water areas in order to measure

exposure. A total of 70 areas for which measurements were available were used for the study. For each drinking water area a weighted mean was calculated of all the measures of each drinking water component. The weighting took into account the length of period of use of each water supply over the previous 10 years (1981-1991) and the relative contribution of each water supply.

The final sample studied included 2,698 non-demented subjects at baseline for which components of drinking water and covariates were available. During the 8-year follow up, 253 subjects were diagnosed with dementia, 17 of these had been exposed to high levels of aluminium (more than 0.1 mg/litre). A total of 182 were classified as having Alzheimer's disease, of these 13 had been exposed to high levels of aluminium. Aluminium levels in water supplies ranged from 0.001 to 0.459 mg/litre. Of the subjects followed up at least once, 63 living in four parishes were exposed to more than 0.1 mg/litre. Silica levels ranged from 4.2 to 22.4 mg/litre.

The risk of dementia and Alzheimer's disease was higher for subjects living in areas where aluminium concentrations exceeded 0.1 mg/litre. After adjustment for age, gender, educational level place of residence and wine consumption the relative risk of dementia was 1.99 (95% CI: 1.20 - 3.28) for subjects exposed to aluminium concentrations greater than 0.1 mg/litre and for Alzheimer's disease it was 2.14 (95% CI: 1.21 - 3.80). Higher silica concentrations (at or above 11.25 mg/litre) were associated with a reduced risk of dementia and Alzheimer's disease and a relative risk of 0.74 (95% CI: 0.58 - 0.96) was calculated after adjustment for dementia and 1.73 (95% CI: 1.55 - 0.99) for Alzheimer's disease.

The authors comment that the findings of this study suggest that a concentration of aluminium in drinking water above 0.1 mg/litre may be a risk factor for dementia and Alzheimer's disease, although no dose-response effect was seen, and case numbers exposed to high aluminium levels were small.



Arsenic

Groundwater arsenic contamination in Bangladesh and West Bengal, India.

Chowdhury UK, Biswas BK, Chowdhury TR, Samanta G, Mandal BK, Basu GC, et al. *Environ Health Perspect* (2000) **108**(5) p393-397.

This paper describes the results of a 10 year survey by the authors in arsenic affected areas of Bangladesh and West Bengal. The total populations in these areas are 80 and 42 million respectively but the percentage of the population suffering arsenic poisoning has not been definitely established. From this survey it was estimated that in West Bengal approximately 5 million people are drinking arsenic-contaminated water at levels greater than 50 µg/L and that nearly 300,000 people have arsenical skin lesions. The survey found that many people in affected villages have elevated arsenic levels in hair, nails and urine even if they do not exhibit arsenical skin lesions. It is predicted that within a few years death across much of southern Bangladesh could be due to cancers triggered by arsenic.

Measurement of low levels of arsenic exposure: A comparison of water and toenail concentrations.

Karagas MR, Tosteson TD, Blum J, Klaue B, Weiss JE, Stannard V, et al. *Am Journal Epidemiol* (2000) **152**(1) p84-90.

This study was undertaken to evaluate the use of toenail arsenic concentrations as a biologic marker of drinking water arsenic exposure. Subjects were controls enlisted in a nonmelanoma skin cancer case-control study of New Hampshire residents aged between 25-74 years. Those less than 65 years were selected from drivers' license records and those greater than or equal to 65 years were selected from Medicare enrolment files.

Participants underwent an extensive interview, which covered residential and medical history and lifestyle factors. Questions were asked about the type of water supply, the duration of use of the current water supply, the number of glasses of water per day from this water source and whether they used filtered water. Interviews took place

between 1994 and 1997. Toenail clippings were collected from participants and analysed for arsenic and other trace elements. In 1995 tap water sampling began from each of the participants homes. These samples were analysed for arsenic concentration.

A total of 540 people were interviewed, of which 506 had toenail samples of adequate weight. A total of 217 water samples were obtained and there were 208 subjects for which both toenail and water analysis was available. Water arsenic concentrations ranged from 0.002 to 66.6 µg/litre. Toenail arsenic concentration ranged from <0.01 to 0.81 µg/litre. Overall the correlation between water and nail arsenic was 0.46 (p<0.001). When water concentrations were at or above 1 µg/litre the correlation was highest at 0.65 (p<0.001). When concentrations were less than 1 µg/litre the correlation was 0.08 (p=0.31). This suggests nail arsenic concentration is useful as a quantitative estimate of low-level arsenic exposure.

Confounding variables in the environmental toxicology of arsenic.

Gebel T. *Toxicology* (2000) **144**(1-3) p155-62.

In several regions of the world many people are chronically exposed to arsenic and are at increased risk of skin cancer and some internal cancers, vascular disorders, peripheral neuropathy and diabetes. The key mechanisms of arsenic tumorigenicity are still not clear and gaps in knowledge make it difficult to assess the level of exposure at which chronic toxicity becomes epidemiologically relevant. This paper looks at some of the possible confounding variables in the environmental toxicity of arsenic.

A comparison of epidemiological studies in Mexico and Taiwan suggest that the susceptibility to arsenic's carcinogenicity may be different between the two populations. Also in the Andes there is evidence that some ethnic groups do not develop skin cancer after long-term exposure to arsenic. The mechanisms that cause differences in susceptibility are still not known.

There are also several compounds which are suspected to modulate the chronic environmental

toxicity to arsenic. These include nutrition factors such as selenium and zinc. Selenium is well known to protect against arsenic toxicity in vitro and in vivo. Selenite suppresses arsenic's toxicity and should be co-analysed in the case of elevated exposure to arsenic in human biomonitoring studies. Nutritional zinc deficiencies have been proposed as a possible enhancer of the vascular effects mediated by arsenic. Arsenic and antimony are found as co-contaminants in the environment. Co-exposure to antimony may be relevant because the element is known to modify arsenic's action. Variations in cancer susceptibilities may be caused by genetic enzyme polymorphisms in the metabolism of arsenic, and also by adapted cellular tolerance to arsenic. Further experimental and epidemiological studies are needed to determine the relevance of these confounding variables and then risk assessment and standard setting for arsenic can be achieved.



Cryptosporidium

Rates of notified cryptosporidiosis and quality of drinking water supplies in Aotearoa, New Zealand.

Duncanson M, Russell N, Weinstein P, Baker M, Skelly C, Hearnden M, et al. *Wat Res* (2000) **34**(15) p3804-12.

Using routinely collected data from June 1996 to August 1998 an ecological study was conducted in Aotearoa, New Zealand to examine the relationship between drinking water quality and reported rates of cryptosporidiosis.

Data for cryptosporidiosis cases included demographic information together with the suburb, town or city, and territorial local authority of residence. For each drinking water supply zone the public health grading, and population size of each community was determined from the register of community drinking water supplies in New Zealand. The compliance with drinking water standards was determined from the annual report on the microbiological quality of drinking water in New Zealand 1996. Rates of notified cryptosporidiosis in each drinking water supply zone were calculated to compare communities of different sizes.

There were 915 cases of cryptosporidiosis reported during the study period. Drinking water distribution zones were identified for 790 cases and they came from 141 registered drinking water supply zones. In New Zealand each drinking-water zone serving 500 or more people has a public health grading consisting of a source and plant grading and a distribution grading.

Almost two-thirds of cases lived in supply zones with a very satisfactory or satisfactory source and plant grading. The highest mean rates of notified cryptosporidiosis were in ungraded drinking water zones and the lowest rates were in zones with a very satisfactory source and plant grading. More than three-quarters of the cases lived in supply zones with a very satisfactory or satisfactory distribution zone grading. The highest mean rates of notified cryptosporidiosis were in the ungraded or marginal or unsatisfactory distribution zones. Rates were lowest in the zones with a satisfactory or very satisfactory grading. Rates of notified cryptosporidiosis were lower in drinking water distribution zones that complied with the New Zealand drinking water standard, compared with non-compliant zones. Rates of notified cryptosporidiosis were highest in distribution zones that were not tested or had failed faecal coliform testing. Rates were lowest in audited zones and in zones which had passed faecal coliform testing.

Residents in small communities in this study did not have the same quality of drinking water as people in major urban centres and also experienced higher rates of cryptosporidiosis. The ecological design of the study means that the influence of confounding factors (such as contact with animals) is unknown, and the higher observed disease rates may not necessarily be attributable to the water supplies. The majority of cryptosporidiosis cases occurred in drinking water zones with satisfactory public health gradings, which complied to New Zealand water standards. Therefore improving water quality will not be sufficient alone to control cryptosporidiosis and other routes of transmission must be investigated, such as recreational water, food and animal contact.



E.coli

Development of a dose-response relationship for *Escherichia coli* O157 : H7.

Haas CN, Thayyar-Madabusi A, Rose JB, Gerba CP. *Int J Food Microbiol* (2000) **56**(2-3) p153-159.

The aim of this study was to develop a dose-response relationship for *Escherichia coli* O157:H7, which could be used for a risk assessment in order to develop guidelines for exposure. As there were no known human dose-response studies for *E. coli* O157:H7 an animal study on the pathogenesis of diarrhoeal disease in New Zealand white infant rabbits was used. Two statistical models were used, a beta-Poisson model and an exponential model. The beta-Poisson model provided a good fit for the dose-response data and showed a statistically significant improvement in fit over the exponential model.

To validate the beta-Poisson model with human epidemiological information, a comparison of the model estimates with human outbreak information was undertaken. Two outbreaks were chosen because fairly accurate information was documented on the vehicles of infection, attack rates and bacterial levels of these outbreaks. One outbreak occurred in Illinois among children who had visited a state park with a lake swimming beach, the other was in an Oregon community where Jerky (dried meat) prepared from contaminated deer meat was consumed. The predicted concentrations in both outbreaks came close to the observed concentrations, giving credibility to the dose-response model.

It has been suggested that *Shigella* can be used as a surrogate for *E. coli* O157:H7 because of the similarity in the toxins produced by the two organisms. A comparison was made of the dose-response models for *Shigella* from prior studies and human dose-response models for other strains of *E. coli* with the present study model of *E. coli* O157:H7. It was found that the dose-response characteristics of *E. coli* O157:H7 are closer to other pathogenic *E. coli* than to *Shigella* and therefore *Shigella* is not an appropriate surrogate.

The findings suggest that the animal dose-response curve is suitable for human risk assessment and that the beta-Poisson model is an appropriate means for extrapolating this relationship to low doses.

Traveler's Diarrhea at Sea: Three Outbreaks of Waterborne Enterotoxigenic *Escherichia coli* on Cruise Ships.

Daniels NA, Neimann J, Karpati A, Parasher UD, Greene KD, Wells JG, et al. *J Infect Dis* (2000) **181**(April) p1491-5.

Enterotoxigenic *Escherichia coli* (ETEC) is a common cause of diarrhoea in travellers and is the most common cause of gastroenteritis outbreaks on cruise ships. Since 1990 the Centers for Disease Control and Prevention have investigated 10 cruise ship outbreaks of ETEC gastroenteritis. This article examines the three most recent outbreaks.

The vehicles of ETEC transmission were contaminated water bunkered by cruise ships in overseas ports, and ice made from this water. Temporary failures in water treatment on two ships seem to have allowed the ETEC to survive. Multiple ETEC serotypes were isolated from patients stool specimens and this may reflect sewage contamination of source water or implicated food vehicles of transmission.

This investigation shows the importance of conducting surveillance for gastrointestinal illness and investigating outbreaks on cruise ships. Ensuring safety of water sources, maintaining water disinfection and monitoring of water quality with up-to-date systems are all important in preventing similar outbreaks in the future.



Helicobacter

How come I've got it? (A review of *Helicobacter pylori* transmission).

Deltenre M, de Koster E. *Eur J Gastroenterol Hepatol* (2000) **12**(5) p479-482.

This paper reviews current knowledge on the risk factors and modes of transmission for *Helicobacter pylori* infection. The main risks are

low socio-economic status and childhood in both developing and developed countries. The routes for *H. pylori* are still unresolved. Although this bacterium can infect some animals, no established ubiquitous animal reservoir has been found and therefore infection by person-to-person transmission has been proposed as the main mode of spread. Some recent evidence suggests that *H. pylori* may persist in the mouth, raising the possibility of oro-oral infection. The faeco-oral route of transmission has also been proposed as a significant mechanism of human contamination in developing countries where hygiene is poor. This transmission may occur through the water supply and may cause primary infection in children and possibly reinfection in adults.



Nitrate

Does the risk of childhood diabetes mellitus require revision of the guideline values for nitrate in drinking water?

van Maanen JMS, Albering HJ, de Kok T, van Breda SGJ, Curfs DMJ, Vermeer ITM, et al. *Environ Health Perspect* (2000) **108**(5) p457-461.

This study investigated the possible association between nitrate in drinking water and the incidence of type 1 diabetes mellitus in children in The Netherlands. A national registry of childhood diabetes in The Netherlands was used to obtain cases. Population data was obtained for three groups of children in the 0-14 years range. Between 1993 and 1995 a total of 1,104 children 0-14 years were diagnosed with type 1 diabetes mellitus, 1,064 of these cases were used in the study out of a total of 2,829,020 children in the analysis.

The mean, minimum and maximum nitrate concentrations were obtained for 3,932 postal code areas in The Netherlands from 1991-1995. Two exposure classification methods were used, the first involved three nitrate concentration ranges of 0-10, 10-25 and above 25 mg/L, the second was based on equal numbers of children exposed to different nitrate levels of: 0.25-2.08, 2.10-6.42, 6.44-41.19 mg/L nitrate. Data on diabetes incidence were correlated with the mean

nitrate concentration in drinking water in the postal code areas. Two different analyses were performed: the chi-square test for trend (univariate analysis) and a Poisson regression model (multivariate analysis) using the two different categories of nitrate exposure. Standardised incidence ratios (SIRs) were calculated for type 1 diabetes in subgroups of the 2,829,020 children with respect to the different nitrate levels, sex and age and as compared in the chi-square test for trend. The incidence rate ratios were compared using the Poisson regression model using nitrate concentration, sex and age as variables.

This ecological study found no effect of nitrate drinking water levels on the incidence of type 1 diabetes. The incidence of type 1 diabetes increased with age. An increased SIR of 1.457 for the nitrate concentration range >25 mg/L was found, however this was not statistically significant as numbers of cases were small. From this study there was no evidence that the intake of nitrate in The Netherlands at present levels in drinking water leads to increased risk of diabetes mellitus type 1, although there is a possible threshold occurrence of this disease at >25 mg/L.

Comment Type 1 diabetes is believed to be caused by an autoimmune process where immune system T-cells attack insulin producing beta-cells in the pancreas. A number of environmental factors have been proposed to play a role including viral infections, early exposure to cows milk, and exposure to nitrosamines, nitrite or nitrate in food or water. This ecological study could not assess genetic background (also a risk factor) or exposure of individual children to nitrate from drinking water as there was no information on residential history, or water consumption habits.



Regulation

Water Quality Laws and Waterborne Diseases: Cryptosporidium and Other Emerging Pathogens.

Gostin LO, Lazzarini Z, Neslund VS, Osterholm MT. *Am J Public Health* (2000) **90**(6) p847-53.

This article examines the overall status of water quality regulation in US states using *Cryptosporidium* to highlight the difficulties posed by emerging and re-emerging pathogens. Results from all 50 states, the District of Columbia, Puerto Rico, and 5 territories are analysed in this article. Information about laws, regulations, policies and practices in relation to water quality and surveillance of cryptosporidiosis in drinking water was obtained. This was analysed for apparent conflicts and gaps in legal authority relevant to public health practice, to identify legal limitations imposed by courts and to suggest areas for state and federal action. Nine problems were identified with existing drinking water regulations on a federal and state level and recommendations were made.



Risk Assessment

Occurrence of pathogenic microorganisms in the Saint Lawrence River (Canada) and comparison of health risks for populations using it as their source of drinking water.

Payment P, Berte A, Prevost M, Menard B, Barbeau B. Can J Microbiol (2000) **46** p565-76.

The aim of this study was to collect data on pathogenic microorganisms along a 300km portion of the Saint Lawrence River (Canada) and to estimate the health risks for the populations using it as their source of drinking water.

Forty-five water treatment plants along the Saint Lawrence River provided samples and data on their operational procedures in order to calculate the theoretical efficiency of each plant's removal of pathogens. Each plant collected 8 litres of raw water before any treatment was used. Most sites were sampled over several months between March 1995 and January 1997. Each sample was analysed for bacterial indicators including: total coliforms and faecal coliforms and *Clostridium perfringens*. Six litres of each sample was used to test for *Giardia lamblia* and *Cryptosporidium parvum* and enteric viruses. Most participating treatment plants completed a detailed questionnaire. Data requested included the physical size and characteristics of all basins in

the plant, operational procedures, the volume and flow rates, the types of treatment including chemicals added, dosages and disinfectant type.

There was a wide variation in the microbial levels in water samples entering the water treatment plants. Some of the sites had low indicator and pathogen occurrence and others very high levels of all contaminants, which reflected the local conditions. The maximum values in raw water were 62 infectious units/litre for human enteric viruses, 38 cysts/litre for *Giardia* and 15 oocysts/litre for *Cryptosporidium*, although it is estimated that losses 50-90% of pathogens occurred in the methods used for detection.

Most of the water treatment plants used conventional treatment followed by rapid sand filtration and disinfection by chlorine. The degree of pathogen removal for each plant was estimated from water treatment parameters, and the concentration of pathogens in finished water was calculated. Removal values showed that a large number of plants did not consistently meet the 3 to 4 log removal goal, or the 1:10,000 annual risk of infection level. Removal values increased in summer. The estimated numbers of pathogens in finished water were incorporated into dose-response model for *Giardia* infection to estimate the annual risk of infection in consumers. The estimated range of probability of infection from *Giardia* was from 0.75 to less than 0.0001 in the exposed populations. However there was no correlation between the estimated degree of risk and reported rates of giardiasis recorded by health authorities in the relevant areas.



Surveillance

Surveillance for Waterborne -Disease Outbreaks - United States, 1997-1998.

MMWR (2000) **49**(SS04) p1-35.

This paper reports on data relating to the occurrence and causes of waterborne-disease outbreaks in the United States from January 1997 to December 1998 and a previously unreported outbreak from 1996. A total of 17 outbreaks associated with drinking were reported by 13 states during 1997-1998. These 17 outbreaks

caused an estimated 2,038 persons to become ill. No deaths resulted and the median outbreak size was 10 persons. The summer and fall months were most commonly associated with outbreaks. For 10 of the 17 outbreaks the infectious agent was known, six were caused by protozoa and four by bacteria. For five outbreaks the cause was unknown and two were due to chemical poisoning.

Giardia caused four of the protozoal outbreaks and *Cryptosporidium* caused two. One of the *Giardia* outbreaks involved 50 people, and was associated with a surface water supply in New York that was chlorinated but unfiltered. Another *Giardia* outbreak occurred in Oregon at a campground and affected 100 people. This outbreak was associated with drinking water from a non-community system that combined with groundwater from an untreated well and a chlorinated spring. Animal contamination was thought to have led to these outbreaks. The two other *Giardia* outbreaks occurred in Florida in 1998. Both were in households where people became ill from drinking untreated groundwater. Recent rainfall and flooding were suspected to have caused the contamination.

The first *Cryptosporidium* outbreak occurred in New Mexico in a children's group home where a contaminated well was implicated. The second *Cryptosporidium* outbreak occurred in Texas and approximately 1,400 people became ill and 23 were hospitalised after more than 160,000 gallons of raw sewage seeped into an aquifer and contaminated four of the five municipal wells. The sewage spill occurred after a lightning strike at a sewage treatment plant.

Three of the bacterial outbreaks were attributed to *E. coli* 0157:H7 and one to *Shigella sonnei*. Two of the *E. coli* outbreaks were associated with contamination of untreated wells the other was associated with a chlorinated groundwater supply at a trailer park. The outbreak of *Shigella sonnei* occurred at a local fair supplied by a community water system where cross-connection was thought to have occurred. A total of 83 people were affected and four were hospitalised. The outbreak was thought to be associated with an earlier

foodborne outbreak. The two chemical outbreaks were due to copper poisoning in Florida. Of the five unidentified outbreaks, four had characteristics consistent with viral syndromes.

Of the 32 recreational water outbreaks 29 were of known infectious etiology. Eighteen of the outbreaks were of gastroenteritis; nine of these were caused by protozoa, four by bacteria, two by viruses and three of unknown etiology. Fifteen of the 32 outbreaks were associated with fresh water and 17 with treated water.

All of the protozoal outbreaks were caused by *Cryptosporidium*. One of these was associated with fresh water and the eight others with treated recreation water, either pools or fountains. Of the four bacterial outbreaks, three were caused by *E. coli* 0157:H7; two in fresh water and one in treated water. The *E. coli* 0157:H7 contamination occurred at a lake resort, a children's pool at a lake. An outbreak of *Shigella sonnei* also occurred and was associated with a wading pool.

The two viral outbreaks were caused by Norwalk-like virus (NLV) and associated with lakes. The three outbreaks for which no agent could be identified were all associated with lakes. There was also one outbreak of Pontiac fever and one of leptospirosis. Eight outbreaks of dermatitis associated with pools, hot tubs, springs or lakes occurred affecting 127 people. The previously unreported outbreak was in Florida and caused by NLV, it was associated with drinking tap water at an elementary school.

Drinking water outbreaks associated with surface water decreased from 31.8% during 1995-1996 to 11.8% during 1997-1998. However groundwater source outbreaks increased from 59.1% during 1995-1996 to 88.2% during 1997-1998. The number of outbreaks caused by protozoa increased in drinking and recreation waters. Data collected here are used to evaluate the adequacy of current regulations for water treatment and monitoring of water quality. The identification of the etiologic agents of outbreaks is important because new methods of control may be required for agents not previously associated with outbreaks.

Viruses

Detection of astroviruses, enteroviruses, and adenovirus types 40 and 41 in surface waters collected and evaluated by the information collection rule and an integrated cell culture-nested PCR procedure.

Chapron CD, Ballester NA, Fontaine JH, Frades CN, Margolin AB. *Appl Environ Microbiol* (2000) **66**(6) p2520-2525.

In order to detect astroviruses, enteroviruses and adenovirus types 40 and 41 in surface water samples, integrated cell culture-reverse transcription-PCR (ICC-RT-PCR) coupled with nested PCR was used. This method was compared to results obtained with the USEPA Information Collection Rule (ICR) method. The ICR method, total culturable viruses assay-most-probable-number (TCVA-MPN), detects viruses on the basis of expression of viral cytopathic effects in Buffalo green monkey kidney (BGMK) cells.

Twenty-nine surface water samples were analysed. The ICC-RT-PCR-nested PCR technique had a higher rate of virus detection for all groups of viruses, and permitted an assessment of infectivity. The authors note that the ICR method may fail to detect a number of viruses, and advocate more sensitive assay methods.

Public health concerns about caliciviruses as waterborne contaminants.

Schaub SA, Oshiro RK. *J Infect Dis* (2000) **181**(Suppl 2) pS374-S380.

This entire Supplement is devoted to articles from a CDC International Workshop on Human Caliciviruses held in March 1999.

This article gives a general overview of the public health concerns about caliciviruses in waters used for drinking, recreation, and shellfish-growing. Caliciviruses include the Norwalk-like viruses (probably the most common cause of infectious gastroenteritis in humans), and are transmitted by the faecal-oral route. They have a low infectious dose and have been associated with disease outbreaks in drinking water, recreational surface

water and in contaminated shellfish. Caliciviruses occur in surface and groundwater and are resistant to environmental conditions.

The US Environmental Protection Agency (EPA) has put calicivirus on its “contaminant candidate list” of emerging or re-emerging pathogens for which regulatory consideration in drinking waters is to be given. Before a regulatory determination can be made scientists and public health officials require information on appropriate methods to sample, detect, identify, and quantify these viruses in faeces and various water media. Adequate methods are also required to establish occurrence, treatability and dose response as well as effects on health.

If it is found that our current treatment and environmental control practices are not effective in controlling human exposure and preventing disease from caliciviruses then future regulatory programs will have to incorporate measures to remove caliciviruses from source waters.

Detection of human and animal rotavirus sequences in drinking water.

Gratacap-Cavallier B, Genoulaz O, Brengel-Pesce K, Soule H, Innocenti-Francillard P, Bost M, et al. *Appl Environ Microbiol* (2000) **66**(6) p2690-2692.

This study examined the drinking water in the homes of children with acute gastroenteritis caused by rotavirus to determine whether rotavirus was present in the water supply. During January to March 1994, samples of 2 litres of drinking water were taken from the homes of 56 children who had been hospitalised for acute rotavirus gastroenteritis in three towns in southeast France. Each water sample was collected within 24 hours of the child being admitted to hospital. Infection was diagnosed by detection of rotavirus antigen in the faeces. During the same period 24 control samples were taken in the same three towns in a public buildings such as schools or city hall.

Using RT-PCR, four of the 56 water samples taken at the homes of infected children were found to be positive. None of the 24 control

water samples were found to be positive. Sequencing of the VP7-amplified fragments of the positive samples showed a single strain of human origin (G serotype 4) and three viruses of animal origin (porcine and bovine). Three children were infected with human strain G serotype 1 and one with human strain G serotype 4 (however this was not the child from the house where G genotype 4 was found in the water).

The authors note that detection of virus by PCR does confirm infectivity, and that there were no correlations between the serotypes present in the water and those in the faeces. However, the water samples taken 24 hours after hospitalisation did not correspond to the water actually consumed by the children. It is therefore not possible in this study to confirm or to rule out the role of drinking water in the occurrence of rotaviral infections.



Water Quality

A survey of the microbiological quality of private water supplies in England.

Rutter M, Nichols GL, Swan A, De Louvois J. *Epidemiol Infect* (2000) **124** p417-25.

The aim of this study was to collect results from regulatory testing carried out on private wells in England to provide a national picture of water quality. This information was then combined with data on the size of the population supplied, water source, treatment and geographical location to examine how these factors affect water quality. Samples were examined for total coliforms and *Escherichia coli*. Information was collected for the period January 1996 to December 1997 on 6551 samples from 2911 supplies.

A total of 1342 (21%) samples from 949 (33%) supplies were positive for *E. coli*. For total coliforms including *E. coli*, 1751 (27%) samples from 1215 (42%) supplies were positive. Supplies providing larger volumes of water were less frequently contaminated with *E. coli* than smaller supplies. Samples taken from borehole supplies were less likely to be contaminated with *E. coli* than samples from surface waters.

Chlorination was the most effective treatment for private supplies however *E. coli* was still isolated from 10% of chlorinated private supplies. For those supplies treated with filtration, 18% were positive for *E. coli* and for those treated with UV light 18% were also positive for *E. coli*. Of the untreated supplies 34% were positive for *E. coli*. There was an increase in contamination of supplies in autumn in both years. The general microbiological quality of private water supplies was poor compared with public supplies.

The effect of domestic ion-exchange water softeners on the microbiological quality of drinking water.

Parsons SA. *Wat Res* (2000) **34**(8) p2369-75.

This study was undertaken to establish whether use of a domestic ion-exchange softener affected microbiological water quality. The softener water quality was tested over 4 months of normal use in a domestic house with two inhabitants and under microbial shock loading conditions in a laboratory.

Water samples were collected from the inlet and outlet of the water softener during normal operation and analysed for total viable count (TVC) at 22 and 37°C. There was no significant difference between the bacterial count at either temperature (less than 1 log increase). Regeneration of the ion exchange resin had a significant effect on the TVC with counts at both temperatures falling after regeneration. The effect of stagnation on TVC after 20 days was investigated and no significant increase in colony counts was found. Analyses were conducted throughout the trial for the presence of *Pseudomonas*, *E. coli* and total coliforms. No *Pseudomonas* or *E. coli* were found. Total coliforms were found in both the inlet and outlet samples. The series of shock loading experiments that were undertaken using a 90L batch of solution containing *E. coli* at 1.9×10^5 /ml found no *E. coli* in the soften water after day 1, although there was a steady increase in TVC. Overall, the tests showed that the ion-exchange softener did not lead to a significant increase the total bacterial count under any conditions tested.

List of Articles

Cancer

Calcium and magnesium in drinking water and the risk of death from breast cancer.

Yang CY, Chiu HF, Cheng BH, Hsu TY, Cheng MF, Wu TN. J Toxicol Environ Health. Part A (2000) **60**(4) p231-241.

Cyanobacteria

Production of novel polyclonal antibodies against the cyanobacterial toxin microcystin-LR and their application for the detection and quantification of microcystins and nodularin.

Metcalf JS, Bell SG, Codd GA. Wat Res (2000) **34**(10) p2761-9.

Disinfection by-products

Potential health effects of drinking water disinfection by-products using quantitative structure toxicity relationship.

Moudgal CJ, Lipscomb JC, Bruce RM. Toxicology (2000) **147**(2) p109-131.

Legionella

Control of legionella in drinking-water systems.

Hoebe C, Kool JL. Lancet (2000) **355**(9221) p2093-2094.

Pathogens

Epidemiology, microbiology, and risk assessment of waterborne pathogens including Cryptosporidium.

Haas CN. J Food Protect (2000) **63**(6) p827-831.

Prevalence of enteric pathogens among community based asymptomatic individuals.

Hellard ME, Sinclair MI, Hogg GG, Fairley CK. J Gastroenterol Hepatol (2000) **15**(3) p290-3.

Water Quality

Valuing discrete improvements in drinking water quality through revealed preferences.

McConnell KE, Rosado MA. Water Resources Research (2000) **36**(6) p1575-1582.

Towards quality assurance of assessed waterborne risks.

Macgill SM, Fewtrell L and Kay D. Wat Res (2000) **34**(3) 1050-1056.

Increase of specific symptoms after long-term use of chlorophenol polluted drinking water in a community.

Lampi P, Vohlonen I, Tuomisto J, Heinonen OP. Eur J Epidemiol (2000) **16**(3) p245-251.



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