ACQWS Paper No. 11

Publication of Water Quality Data - 2002

Background

1. Pursuant to ACQWS Paper No. 2 and ACQWS Paper No. 4 and with the endorsement of the Members, Water Supplies Department (WSD) in August 2000 published on the Internet the first annual report on drinking water quality data for physical parameters, chemical parameters of health significance (including inorganic constituents, organic constituents, pesticides and disinfectant by-products), and bacteriological quality for the period of 1 April 1999 - 31 March 2000.

2. Although it is not a worldwide practice to release raw water quality data, WSD has also published water quality data on Dongjiang water as received at Muk Wu Pumping Station in view of public interest on the subject.

3. In July 2001, WSD updated the annual report for the period 1 April 2000 - 31 March 2001.

4. By July 2002, WSD should be able to update the annual report for the period 1 April 2001 - 31 March 2002. In this report, WSD proposes to include the monitoring data on samples examined for *Cryptosporidium* and *Giardia* (C&G).

5. For more background information on the subject, please refer to **Annex 1**.

Advice Sought

6. Members' views on the subject are sought.

Water Supplies Department
March 2002

***Cryptosporidium* and *Giardia* (C&G)**

1. C&G are microscopic parasitic protozoa, which can infect the gut of cattle, sheep, wild and domestic animals, and man. They occur in all surface waters and even in some ground waters. Infection of humans mostly occurs through person to person transmission owing to inadequate personal hygiene after contact with a source. Infection through ingestion of food or water contaminated with C&G is also possible.

Health effects

2. Surveys have been conducted on the prevalence of *Cryptosporidium* in the environment. In industrialized nations, around 0.4% of the population appears to be passing oocysts in the faeces at any one time. Of those patients admitted to hospitals for diarrhoea, about 3 % are passing oocysts. 30-35% of the US population have antibodies to *Cryptosporidium parvum.* In third world countries, the percentage is even higher up to 60-70%. It is evident that the presence of the parasite is ubiquitous.

3. When a person is infected by a sufficient number of oocysts or cysts, the illness caused by *Cryptosporidium* is called "cryptosporidiosis". Currently, there is no world-wide consensus on the infectivity of the *Cryptosporidium* oocyst on humans. The disease resulting from infection by *Giardia* is called "giardiasis". As few as 10 *Giardia* cysts may cause the illness.

4. Most people may not develop symptoms if they drink water containing C&G. Symptoms of infection in healthy individuals are self-limiting diarrhoea. In more severe cases, patients may develop abdominal pain, diarrhoea, malabsorption, fatigue and weight loss. Most people infected by C&G will recover from the illness without medication. Humans appear to have various degrees of susceptibility to this parasite and the infectious dose will probably vary between individuals and among different strains. People who have compromised immune systems e.g. those with human immunodeficiency virus (HIV) infection or acquired immune deficiency syndrome (AIDS) or organ transplant patients are more at risk from this infection.

Outbreaks of Cryptosporidiosis and Giardiasis

5. It is only in the last 20 years that *Cryptosporidium parvum* (the species of *Cryptosporidium* that infect humans) has been recognized as an important waterborne pathogen, though the first human case of cryptosporidiosis was diagnosed in 1976 [1]. From 1976 to 1982, reported cases were primarily associated with immunocompromised people. In 1982, the number of reported cases began to increase dramatically in conjunction with the spread of AIDS. With recent developments in laboratory diagnostic techniques, outbreaks among immunocompetent individuals began to be recognized.

6. During the past 25 years, waterborne protozoa have been a significant cause of outbreaks of cryptosporidiosis and giardiasis. Most of the outbreaks in the USA have been attributed to contaminated surface waters treated only by disinfection **without** filtration.

7. The most notable waterborne outbreak of cryptosporidiosis was the one that occurred in Milwaukee, Wisconsin, U.S.A. in 1993 [1 - 3]. Approximately 400,000 people became ill and 4,400 people were hospitalized. The outbreak was responsible for the premature deaths of about 60 individuals, most of whom were HIV-positive. The precise source of contamination in the Milwaukee outbreak was **not** identified; possible sources of *Cryptosporidium* included cattle wastes, slaughterhouse wastes, and sewage. It was speculated that rivers transported the oocysts from these sources to Lake Michigan during a period of high flow that resulted from the combined effects of spring rains and snowmelt.

8. Even if C&G are present in the water supply system, outbreaks may **not** occur because the oocysts and cysts may have lost viability due to prolonged exposure to environmental stresses, or may have been damaged by water treatment processes. An example is given by the event in Sydney, Australia during July - September 1998. During this period, C&G were allegedly detected in water samples and exceptionally high readings of these species were reported: up to 1529 *Cryptosporidium* per 100 litres in one sample and 3952 *Giardia* per 100 litres in another [4]. However, **no** waterborne outbreaks of cryptosporidiosis and giardiasis had been reported. It was later found that many of the C&G organisms present appeared to be degraded and were unlikely to be capable of causing infection [5]. In some cases the reported levels of C&G were overestimated or wrongly identified.

9. It must be stressed that drinking water is **not** the only possible route of transmission of *Cryptosporidium* or *Giardia*. Recreational waters, food, person-to-person and person-to-animal contacts are also possible means of transmission [6].

Standards for C&G

10. A treatment standard for *Cryptosporidium* oocyst was established by UK Drinking Water Inspectorate in June 1999 [7]. According to the standard, treated water leaving the treatment works should contain less than an **average** of 1 *Cryptosporidium* oocyst in 10 litres of water. It must be stressed that this UK treatment standard on *Cryptosporidium* oocyst is **not** a health-related standard as there is **no** requirement for the viability of the oocyst to be determined i.e. distinction between viable (infectious) and nonviable (not infectious) oocysts is not required. The treatment standard is based on the attainability of well-operated treatment works. This standard is applicable to **England and Wales only** and is not known to be accepted elsewhere.

11. To-date Europe, USA, Australia as well as the World Health Organization have not set guideline values or standards for C&G in drinking water on health basis.

12. The Code of Federal Regulation of the USA requires that "if a system utilizing microparticulate analysis for USEPA compliance finds greater than 5 *Giardia* cysts or 50 *Cryptosporidium* oocysts per litre of water, the system **may**, at the discretion of the State Epidemiologist or Drinking Water Program, be placed on a precautionary Boil Water Order. Care should be exercised by the State **not** to place unwarranted Boil Water Order. A system finding a result between 1 and 5 *Giardia* cysts and 5 to 49 *Cryptosporidium* oocysts per litre of water will be required to undergo Public Notification and should attempt to notify the immuno-compromised population that may be at risk".

13. Methods for detection of Cryptosporidium oocysts and Giardia cysts in water are described in the **Appendix** to this Annex.

Water Treatment

14. There is limited information and data available on the inactivation of C&G by chemicals such as chlorine or other oxidants. Initial indications suggest that chlorine and chloramines are relatively ineffective biocides when employed for inactivation of *Cryptosporidium* oocysts [9]. Moreover, disinfectant studies have demonstrated ozone's potential to inactivate *Cryptosporidium* oocysts by 2-log at achievable residual concentration and contact time [10]. Ozone is also a more effective disinfectant for the inactivation of *Giardia* cysts than chlorine [6].

15. Modern water supply practices offer a number of barriers to the spread of C&G. Natural purification by storage in reservoirs enables the oocyst/cyst to be removed by sedimentation. The combined treatment process of coagulation, sedimentation followed by filtration is known to be an effective barrier for protozoan oocysts or cysts. The use of conventional two-stage water treatment process as is practised in Hong Kong is effective in removing the oocyst/cyst of C&G. It is commonly recognized that conventional two-stage water treatment i.e. clarification and filtration run within design parameters will generally be effective to achieve 99 to 99.9% removal of the organisms. A raw water level of say 10 *Cryptosporidium* oocysts/litre may therefore be reduced to 0.01 - 0.1 oocyst/litre by such treatment.

16. In Hong Kong, all raw waters are fully treated by prechlorination, coagulation with aluminium sulphate, filtration through rapid gravity filters, preceded at almost all treatment works by a sedimentation stage, disinfection by chlorine, pH correction for corrosion control, and fluoridation. After filtration, chlorine is added to achieve a final free residual chlorine concentration of about 1.0 mg/l of water when it leaves the treatment works. With proper process design and well-managed operations, Hong Kong's treatment works produce drinking water in compliance with the WHO water quality standards and is safe for consumption.

Monitoring of C&G in raw water

17. A total of 20 raw water samples including Dongjiang water and local reservoir water has been examined by the WSD during the period from November 1999 to March 2002.

The organisms are **ubiquitous** in the natural environment i.e. they occur everywhere. Low levels of C&G may be present in Dongjiang water. *Cryptosporidium* was detected in 2 samples ranging from 0.29 to 0.80 oocysts per litre of water. *Giardia* was detected in 5 samples ranging from 0.01 to 5.88 cysts per litre of water.

Monitoring of C&G in treated water

18. A total of 90 treated water samples has been examined by the WSD during the period from April 1999 to March 2002. *Cryptosporidium* was detected in 3 samples ranging from 0.01 to 0.10 oocysts per litre of water. No *Giardia* has been detected in the tests conducted during this period. Positive testing results of *Cryptosporidium* during the period from April 1999 to March 2002 are as follows : -

Date	Location	*Cryptosporidum* oocyst per litre
1.4.1999	Sha Tin T/W Stage II	0.06
9.8.1999	Sha Tin T/W Stage II	0.10
6.12.2000	Au Tau T/W	0.01

19. According to the information and experience of the water supplies industry in other parts of the world, such levels of parasite can be considered as very low. Our treated water is subject to stringent quality monitoring and when necessary, consumers will be advised of the need to boil the water before consumption to ensure safety. The detection of low level of C&G in water does not mean that the water is not safe for consumption.

20. In 2000/2001, over 25,000 water samples were taken from treatment works, service reservoirs and consumer taps for bacteriological examinations. The results indicated that all samples complied with the guideline values recommended by the World Health Organisation i.e. Coliform or E. Coli bacteria were not detectable in any 100 ml sample. The use of intestinal organisms, typically faecal coliforms, as faecal contamination indicators is an universally

accepted practice for monitoring and assessing the microbial safety of water supplies.

21. Up to the present, **no** outbreak of cryptosporidiosis or giardiasis due to ingestion of water has occurred in Hong Kong. The Department of Health has established a surveillance system through stool testing of diarrhoeal patients attending the general out-patient clinics to monitor the trend of such infections in the community.

22. In view of the public concern for the microbiological quality of the drinking water supply in Hong Kong, WSD has commissioned a consultancy study to look into proactive prevention measures to minimise the risk of C&G in drinking water and to formulate a contingency plan for dealing with these parasites in water supply. The study was completed in March 2001. Mechanisms for disease surveillance and outbreak control have been established by the Water Supplies Department and the Department of Health.

References

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3. K. R. Fox, D.A. Lytle 'Milwaukee's crypto outbreak: investigation and recommendations', Journal of American Water Works Association, p. 87 - 94, September 1996.

4. Cooperative Research Centre for Water Quality and Treatment, Health Stream, Program 1 Newsletter, Issue 11, September 1998.

5. The Summary of the 3rd Report of the Sydney Water Inquiry on the Assessment of the contamination events and future directions for the management of the catchment.

6. World Health Organisation 'Guidelines for drinking-water quality, Volume 2, Health criteria and other supporting information' 2nd Edition, Chap. 5, 1996.

7. Statutory Instruments 1999 No. 1524, the Water Supply (Water Quality) (Amendment) Regulations UK,1999.

8. W. Jakubowski, S. Boutros, W. Faber, R. Fayer, W. Ghiorse, M. LeChevallier, J. Rose, S. Schaub, A. Singh, M. Stewart 'Environmental methods for *Cryptosporidium* - A number of approaches offer promise for addressing the limitation of current antibody based detection methods' Journal of American Water Works Association, September 1996.

9. A Braghetta, J Jacangelo, R Rhodes Trussell, J Meheus 'The Practice of Chlorination: Application, Efficacy, Problems and Alternatives' The blue pages of the IWSA information source on drinking water issues.

10. World Health Organisation 'Guidelines for drinking-water quality, Volume 2, Health criteria and other supporting information' 2nd Edition p.112-114,1996.

Methods for Detection for *Cryptosporidium* oocysts and *Giardia* cysts in Water

1. Essentially all the methods available for the detection of *Cryptosporidium* oocysts or *Giardia* cysts include three stages: sample collection and concentration, separation of oocysts/cysts from spurious debris, and microscopic examination for oocysts/cysts. Most methods have centred around microscopic examination of fluorescent antibody-stained concentrates from large volumes of water samples in the order of 100 to over 1,000-

5. A summary of the procedure is described below:-

The water sample is filtered through a foam filter of nominal pore size 1 μm at a rate of **not** more than 1.5 litres per minute. Materials on the filter are removed by elution with an aqueous buffered salt and detergent solution. The eluate is centrifuged to pellet the oocysts and cysts, and the supernatant fluid is aspirated. The oocysts and cysts are magnetized by attachment of magnetic beads conjugated to anti-*Cryptosporidium* and anti-*Giardia* antibodies. The magnetized oocysts and cysts are separated from the extraneous materials using a magnet, and the extraneous materials are discarded. The magnetic bead complex is then detached from the oocysts and cysts. The oocysts and cysts are stained on well slides with fluorescently labeled monoclonal antibodies and 4',6-diamidino-2-phenylindole (DAPI). The stained sample is examined using fluorescence and differential interference contrast (DIC) microscopy.