2 Introduction

2.1 Re-establishment of the Expert Group

2.1.1 In response to the outbreaks of cryptosporidiosis in Swindon and Oxfordshire in 1989 the Secretary of State for the Environment, jointly with the Secretary of State for Health, established an Expert Group to advise upon the significance of Cryptosporidium in water supplies. The Expert Group was chaired by the late Sir John Badenoch and reported in 1990 (Badenoch 1990). The Expert Group’s recommendations were accepted by the Government and resulted in the establishment of a national research programme, which was steered by the Drinking Water Inspectorate (DWI) and has been reviewed in two reports (DOE 1992; DOE 1994). The Expert Group also made recommendations on reducing the risk of infection, ways to prevent Cryptosporidium getting into water supplies, monitoring strategies and investigation and management of outbreaks. In England and Wales DWI has monitored water utility implementation of these recommendations through its inspection process and similar checks have been carried out in Scotland by the Scottish Office.

2.1.2 The Expert Group was reconvened in 1994 to evaluate research findings and to assess the experiences of implementing its recommendations. The Expert Group’s second report, which was published in 1995 (Badenoch 1995), included an authoritative and independent assessment of treatment requirements for Cryptosporidium. The report also made a number of recommendations on good practice, particularly on monitoring and operation of water treatment. The Expert Group concluded that properly operated conventional water treatment processes designed for removal of particulate material are usually very effective in removing Cryptosporidium oocysts from water.

2.1.3 The outbreak of cryptosporidiosis in north west London and Hertfordshire in early spring 1997 was associated with drinking water derived from underground strata. Such sources had generally been considered to be at very low risk of contamination by Cryptosporidium. It was important also to review the experience gained in water treatment and in outbreak management since the publication of the Second Report. Ministers therefore decided to re-establish an Expert Group on Cryptosporidium in water supplies under the chairmanship of Professor Ian Bouchier. Membership of the Expert Group is shown at the beginning of this Report.

2.2 Terms of reference

2.2.1 The terms of reference for the Expert Group are:

- to assess the lessons learned from suspected waterborne outbreaks of cryptosporidiosis;
- to consider the results of research carried out since publication of the Second Report of the Group of Experts;
to consider whether there is a need for further advice on: protection of water resources, including surface and groundwaters; provision of additional water treatment; design of monitoring programmes and strategies; management of outbreaks of drinking water related illness;

- to consider whether further research is appropriate; and

- to report jointly to the Secretary of State for the Environment, Transport and the Regions and the Secretary of State for Health.

2.3 Format of the Report

2.3.1 Much of the advice given in the 1990 and 1995 Expert Group reports (Badenoch 1990; 1995) remains sound and is supported by the results of subsequent research. No attempt has been made in this Report to repeat the considerable body of information in the previous reports but rather to add to it where further data or information are available. The main recommendations from the two previous reports are listed in Appendix A1 and where necessary the Group has added comments.

2.3.2 The Report is written in the context of the administrative arrangements for water supply, health care and local government in England and Wales and in Scotland. The Water Supply Regulations are administered in England and Wales by DWI and the Scottish Office Environment Department and the Northern Ireland Environment and Heritage Department. DWI have broadly similar functions in Scotland and Northern Ireland respectively. Much of the advice will be applicable outside the UK even where different administrative arrangements apply.

2.3.3 The main report is quite short and should be of value to both the technical and non-technical reader. Much of the detailed information is included as Appendices rather than in the body of the report. During its deliberations the Group has collected information on some topics which do not fall strictly within its terms of reference, such as the use of water by the food industry. Where the Group considers such information could be of use to a wider audience, and was not covered by the two previous reports, it is included. A paper on bottled water is included in Appendix A5.

2.3.4 This Report reviews: knowledge gathered and research carried out since the 1995 report; the lessons learnt from the analysis of outbreaks of waterborne cryptosporidiosis; the functioning of Incident Management Teams (IMT) and Outbreak Control Teams (OCT); the limitations of epidemiology and analysis; and the potential risks to groundwater. Where appropriate, recommendations for improvement are made. Advice is given to water utilities, IMTs and OCTs, immunocompromised people, the food industry and users of private water supplies. Topics for future research are identified.

2.3.5 Subsequent paragraphs in this section highlight very briefly the organism, the disease and the problems associated with water treatment and sampling and analysis of water supplies.

2.4 Cryptosporidium parvum

2.4.1 Cryptosporidium is a protozoan parasite found in man, many other mammals and also in birds, fish and reptiles. The only species known to infect both man and livestock is Cryptosporidium parvum. In the infected
animal, the parasite multiplies in the gastrointestinal tract. The animal then excretes oocysts of the parasite in its faeces in very large numbers, for example it is known that infected calves excrete approximately $10^{10}$ oocysts daily for up to 14 days and it is likely that humans shed a similar number.

2.4.2 *Cryptosporidium* oocysts are tiny spore-like structures, four to six micrometres in diameter, which carry within them the infective form, the sporozoites. When ingested by another host they can transmit the disease and set up a new cycle of infection. The oocysts are very resistant to adverse conditions in the environment and can survive dormant but viable for months in clean water or moist cool soil.

2.5 *Cryptosporidiosis*

2.5.1 In normal healthy individuals, cryptosporidiosis is usually characterised by an acute self-limiting diarrhoeal illness, commonly of two to three weeks duration, from which the patient recovers fully. In patients who are immunocompromised the disease is likely to be much more serious. The infective dose for humans is not known with any confidence but is thought to be quite low. As yet there is no effective specific treatment.

2.5.2 The prevalence of *Cryptosporidium* in livestock makes it likely that most oocysts in the environment derive from agricultural sources and wastewater discharges. However, recent studies have shown that human strains not derived from livestock are the prevalent form in at least some human waterborne outbreaks (see Appendix A7). All types of environmental water can become contaminated and oocysts may be present in low numbers in most waters from time to time. Drinking water is recognised as a vehicle for transmission although usually only when treatment is inadequate or compromised. There is always a low level of cryptosporidiosis in the community and it is unlikely that drinking water is a major cause of this background level. Sources other than human or livestock derived oocysts in water include contact with farm and domestic animals, swimming pools, food and milk. Cryptosporidiosis can be spread from animals to man and by person to person contact.

2.5.3 The evidence is now overwhelming that there are identifiably distinct ‘strains’ or sub-types (genotypes or lineages) of *C. parvum* and that one such sub-type appears on current evidence to be restricted to man. The evidence of a high prevalence of a ‘human genotype’ in three waterborne outbreaks has considerable significance in relation to transmission by the water route, suggesting that sewage effluent may have been the major source of these outbreaks. See Appendix A7.

2.5.4 Studies in healthy volunteers have shown that administration of 30-40 *C. parvum* oocysts is sufficient to initiate human infection (DuPont *et al* 1995). In view of the variable viability of oocysts in drinking water and the difficulty in confirming viability of oocysts obtained by filtration during routine surveillance of drinking water, it is unlikely that it will ever be possible to establish confidently a ‘safe limit’ of oocyst concentration.

2.6 *Cryptosporidium* and water treatment

2.6.1 The presence of *Cryptosporidium* oocysts in source water presents a particular challenge to water utilities because oocysts are resistant to the
standard chlorine disinfection regimens used for drinking water treatment and can be present in treated water in the absence of conventional bacterial indicators used to assess the efficiency of disinfection.

2.6.2 Conventional physical/chemical water treatment processes such as coagulation, sedimentation, dissolved air flotation (DAF), rapid gravity filtration and slow sand filtration were not designed to deal specifically with the problem of *Cryptosporidium* oocyst removal. However, such treatment can provide an effective barrier provided that the appropriate level of treatment for the raw water source has been installed and it is operated properly. However, if treatment is inadequate or compromised, significant numbers of oocysts may pass into the treated water supply. The use of membrane technologies can further improve oocyst removal.

### 2.7 Sampling and analysis

2.7.1 The analysis for most micro-organisms of relevance to the water industry involves starting from very low numbers, often one organism is sufficient, and growing them in artificial media or tissue culture until they are present in sufficient numbers to give a reliable result. Current routine analytical methods for *Cryptosporidium parvum* do not utilise any form of growth stage, so initially viability is not known. Oocysts have to be concentrated from large volumes of water, separated from contaminating debris, detected and, if practicable, tested for viability. Each stage can introduce large errors and recovery efficiencies as low as 1% have been reported.

2.7.2 Sampling and analysis for *Cryptosporidium* is presently the subject of considerable research worldwide. Significant advances have been made both in filtration and separation technologies and in the procedures for concentration of the organism prior to identification. Routine demonstration of oocyst viability is not reliable.

### 2.8 Proposed Regulation for *Cryptosporidium*

2.8.1 At the beginning of May 1998, the Department of the Environment, Transport and the Regions issued a consultation document, *Preventing Cryptosporidium getting into Public Drinking Water Supplies* (DETR 1998). This stated that Ministers had concluded that there is a case for increased monitoring at water treatment plants that are most at risk of releasing *Cryptosporidium* into drinking water supplies and have proposed amendments to the Water Supply (Water Quality) Regulations applying to England and Wales (Anon 1989). These propose a treatment standard of less than one oocyst in 10 litres based on continuously sampling 1000 litres of treated water per day. The document includes a number of issues for consultation. Although the consultation paper was not referred to the Group for consideration, the issues of particular interest to the Group are:

- the rationale behind a treatment standard;
- whether the proposals cover those sources of greatest risk; and
- the use of continuous sampling.

2.8.2. It is understood that the proposed treatment standard has been derived from experience of routine samples in which the concentrations found in water treated according to accepted good practice were at least an order of magnitude lower than 1 oocyst in 10 litres and there was no increase in cryptosporidiosis in the community. The Group further
understands that the information available on infectivity, although limited, indicates that an infective concentration is at least an order of magnitude greater than 1 oocyst in 10 litres. The Group does not have any additional information on which to offer a different number to that proposed.

2.8.3. The analysis of outbreaks given later in the Report confirms that the greatest concern is on river sources which would be covered by the proposals as presented in the consultation paper. However there are other high risk situations, such as some groundwaters influenced by surface water, which do not have treatment appropriate for surface waters, and which do constitute an equivalent risk. The Group would like to see such sources included on a risk assessment basis.

2.8.4. The Group confirms, as concluded in the earlier Expert Group reports, that random spot sampling for Cryptosporidium is ineffective, as the chance of a sample being taken just as a pulse of Cryptosporidium is passing through the treatment works is very low. One solution is to introduce continuous sampling on high risk sites. The Group has received a preliminary report on the trials held on continuous sampling methods which show that one system is capable of processing 1000 litres of sample in a day for a variety of different treated waters with satisfactory and consistent recovery during analysis. This has confirmed the feasibility of continuous sampling for routine monitoring. The Group, although not commenting on the proposed regulations, recommends continuous sampling (see paragraphs 5.3.9 and 5.3.10) as one method of improving the effectiveness of monitoring in protecting public health.

2.9 Continuation of the Expert Group

2.9.1 The re-establishment of the Expert Group acknowledges the need to re-consider Cryptosporidium as a water supply issue in the light of experience gained in water treatment and outbreak management. The Group is aware that research and development is continuing around the world and it identifies an on-going need to consider whether additional advice is necessary and identify topics requiring further research. It considers that this would be best resolved by re-convening the Expert Group every two years.

**Recommendation**

2.9.2 The Expert Group should reconvene at two yearly intervals to consider, in the light of experience, whether additional advice should be issued and identify topics where further research is needed.

**References**


