

# Cryptosporidium and giardia lamblia in private water supplies

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The health problems associated with waterborne *Cryptosporidium* and *Giardia lamblia* are well known. Up to 400,000 people were affected in the largest recorded outbreak of *Cryptosporidium*, in Milwaukee in the USA. As well as being a major dilemma for water companies, these protozoan parasites are also a problem for environmental health officers.

There are risks of *Cryptosporidium* associated with private water supplies that do not apply to mains water. These are:

- the immediate proximity of young farm animals to many supplies;
- the inadequate protection of many sources leading to rainwater washing faecal material into the collection point; and
- the absence of treatment to many supplies and the inadequacy of the treatment systems that are installed.

The Private Water Supplies Regulations 1991 (HMSO, 1991) [5] do not require private water supplies to be monitored for *Cryptosporidium* or *Giardia lamblia*. They rely on the presence of a single faecal indicator organism (faecal coliforms) to alert local authorities to the possible contamination by pathogens. Because of its longevity *Cryptosporidium* may be isolated in water where the coliform population has become inactive.

Because of these theoretical risk factors, Bradford and District Metropolitan Council successfully applied to the Department of the Environment for research funding to investigate the problem. During the winter period of 1996/7 with Craven District Council we regularly tested 15 high-risk supplies to find out the extent of the problem. We selected as wide a variety of supplies as possible within that risk category. All the sites were spring and surface water supplies rather than boreholes. They included commercial and domestic supplies and the population using the water ranged from one house to a whole village.

## Rainfall Effects

Previous studies of environmental water samples have often indicated an association between rainfall and *Cryptosporidium*. [9] There has been found to be an increase of cases in the early spring with a second lesser peak in the mid autumn period. It has been proposed that these peaks coincide with high rainfall. [1] This is also the time of farming events such as slurry and muck spreading, lambing and calving. There appears to be a corresponding association with general contamination of private water supplies at these times. [8]

The connection between rainfall and contamination is relevant because monitoring should take place at the time when conditions are most likely to produce the poorest results. We therefore sampled just after significant precipitation events when, should contamination occur, we would have a reasonable chance of finding it. Sampling therefore normally followed times of rain. The only samples that were not taken within two days of rain were those following periods of snow. The sampling then took place the day after a thaw.

## Indicator Organisms

One of the problems with coliform indicators is that they are subject to comparatively rapid die off due to environmental stress. Hence they are often considered less than adequate as a measure of remote or historic faecal contamination. Consequently we decided to use the traditional organism for identifying this type of contamination, *Clostridium perfringens*. It is a spore forming bacteria of exclusively faecal origin. The spores can be considered as an approximation of the oocyst.

*Faecal streptococci* were also chosen as another potentially useful indicator. They are more resistant to environmental stress than coliforms and generally persist longer in the environment, although not as long as *Clostridium perfringens*. Thus their presence will not so readily give rise to over reaction to past pollution events.

Because of various factors local authorities do not normally look for *Cryptosporidium* in their private water supplies. It seems appropriate however that only parameters which are health related and of particular concern in a catchment should be monitored. One of the intentions of the study was to see whether *Cryptosporidium* and *Giardia lamblia* should be included within this category.



David Clapham (left) and Professor Bouchier, Chair of the Group of Experts on *Cryptosporidium*, compare notes on a private supply

## Methodology

Fifteen sites were selected and sampled ten times each. The aim of the study was to select supplies that were worst cases and to sample them when they were most likely to be contaminated. In that way if *Cryptosporidium* and *Giardia lamblia* were going to be found in private water supplies our methodology should find them.

Supplies were rated on a number of points, including:

- type of supply, ie. spring or surface supply,
- source protection,
- quantity of animals on or up hill from the site, condition of collection chambers, tanks and pipework, and
- previous results for faecal coliforms.

The sampling was carried out according to the procedures laid down in Report 71, 'The Microbiology of Water 1994, Part 1 - Drinking Water'. [7] All sampling took place early in the morning and samplers were required to visit at approximately the same time for each site. This was to remove the effect of any possible diurnal variations in contamination load.

## Results

During the sampling period nine of the 15 supplies were found to contain *Cryptosporidium* (60 per cent). In addition, eight of the supplies also contained *Giardia lamblia* (53.3 per cent). *Cryptosporidium* was found in 21 (14 per cent) of the 150 samples taken. This ranged from nil positive results in some of the supplies to 40 per cent of the samples in the most highly contaminated. Twelve positive results for *Giardia lamblia* cysts were found in the samples (8 per cent). Of the 21 positive results for *Cryptosporidium*, 57.1 per cent were also positive for *Giardia lamblia*

We also looked at other parameters of water quality to try and establish a link between them and *Cryptosporidium*. Statistically significant correlations to *Cryptosporidium* for *Faecal streptococci* ( $r = 0.6783$   $p < 0.001$ ) and *Clostridium perfringens* ( $r = 0.6268$   $p < 0.001$ ) were found.

There was no significant correlation in this study between *Cryptosporidium* and coliforms (either total or faecal), turbidity, conductivity or the sanitary assessment score.

The use of a combination of indicators may identify potential problems. Multiple regression analysis with turbidity, faecal and total coliforms, *Faecal streptococci* and *Clostridium perfringens* gave an  $R^2$  value of 0.6259. This shows that 62.6 per cent of the variation in *Cryptosporidium* levels could be accounted for by these factors. It should be emphasised that this is not a causal relationship. The benefits, however, of including *Faecal streptococci* and *Clostridium perfringens* in sampling programmes are clear.

## Discussion

The study concentrated on predominantly high risk supplies that were sampled at times when contamination would be expected to be high. Private water supplies that do not have reasonable source protection, (even bearing in mind the lack of significant correlation between the sanitary survey score and *Cryptosporidium*) can be considered to be at risk.

There is an absence of *Cryptosporidium* in the samples taken from some of the high risk supplies. One explanation for this and the lack of correlation with the sanitary score could be the poor recovery rates associated with the detection methods involved. Another could be a defect in the sanitary survey assessment.

In order to investigate this possibility we looked at the indicators of faecal contamination. 98.6 per cent of samples showed some form of faecal contamination. The levels of faecal indicators were almost uniformly high with a faecal coliform mean of 224.5 per 100 ml and a maximum of 6000 per 100 ml. Similar figures apply to the other microbiological indicators. This would seem to indicate that our definition of high risk was reasonably accurate for general contamination levels.

The results can also be looked at from a monthly average point of view. In November, 22.8 per cent of samples were positive for *Cryptosporidium* compared with 14.8 per cent in December, 11.4 per cent for January and 11.1 per cent for early February. If November is looked at separately the first half of the month gave 24.4 per cent positive samples compared with 12 per cent for the second half. This indicates that the first half of November may be the down slope of the autumn peak and that the December, January and February levels are the background. There could of course be other reasons for this difference, although other factors such as time of day and rainfall have been largely negated by the design of the study.

The winter low period is probably due to fewer animals being on the catchment to provide fresh oocysts and the absence of slurry spreading. Cattle for example, will have been brought down from the hills in late November for protection. Cryptosporidiosis is also primarily a disease of young animals. By November most young animals in the area have been sent to the slaughterhouse. The sheep on the high grounds, where the majority of the private water supplies were located will mainly consist of pregnant ewes, a small number of yearlings to supplement the breeding population and a few rams. This population will not be ones that would be expected to produce oocysts in the numbers associated with lambs.

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## **Cryptosporidium and giardia lamblia in private water supplies. Part II**

### **Problems With Sampling and Faecal Coliforms, Conclusions and Recommendations**

#### **Sampling Methods**

We used two methods of sampling to assess their relative recovery efficiency. The majority were 10 litre grab samples analysed by flow-cytometry, the rest used a filter mechanism to trap the oocysts from larger amounts of water (up to 200 litres). The reason for using two methods was to assess their relative recovery efficiency. The results were somewhat disappointing in that during the time when we used both methods the majority of the results were negative and no comparison could be made. Two supplies however did have a different result for the two methods. They both found *Cryptosporidium* in the 10 litre grab sample and not the filter. This was also true for one of these supplies that also had *Giardia lamblia* in a grab sample but not in the filtered sample.

The practical difficulties involved in taking the filter samples however were such that they can be considered unrealistic as a method for use by local authorities except on very rare occasions. There has to be at least two visits for each sample. Two supplies had to have six visits and another two had four visits due to problems with getting sufficient water through the filter. Some local authorities have private water supplies over two hours away by road and the costs and staff time involved are prohibitive. The filters need water under pressure either using a tap or more complicated procedures with a pump and connection to mains electricity or a car battery. They have to be left for long periods either over night or throughout the day usually in remote but public places and may be damaged or stolen. Householders were much more resistant to the use of the filters. This was because they did not want them running overnight thus causing their tanks to continually run, did not want to risk using all the supply in the tanks or just felt that the method was a waste of water.

The 10 litre grab sample appeared to be a much more efficient method of sampling and is preferable if it has similar recovery rates of protozoan parasites to the filter method. Fricker (1995) [4] and Watkins, Kemp and Shepherd (1995) [10] have indicated this is the case with flow cytometry, particularly with dirty samples (which would therefore make them particularly applicable for private water supplies).

#### **The Adequacy of Current Indicator Organisms for Faecal Contamination**

Fourteen of the fifteen supplies (93.33 per cent) were recorded as having very low faecal coliforms (ten or less) at some time during the study. Due to the sensitivity of the membrane filtration method, rates of one to ten faecal coliforms can be

considered as being very low and there is the possibility that another sample taken at the same time would have registered as nil faecal coliforms per 100 ml.

Table one details the number of times this occurred during the study, what the maximum number of faecal coliforms were recorded from the same source during the study and the number of times *Cryptosporidium* and *Giardia lamblia* were identified.

Source code	Number of times very low faecal coliforms results	Maximum number of faecal coliforms recorded at the site	Number of times positive for <i>Cryptosporidium</i>	Number of times positive for <i>Giardia lamblia</i>
ACA	6	400	0	0
ACB	1	1920	1	0
ASPA	4	5600	4	1
ASPB	5	700	0	0
CA	5	128	0	0
CC	1	1200	1	1
CD	1	250	4	3
CE	2	800	2	1
DCA	3	300	0	0
DCB	8	1000	0	0
NFA	1	6000	3	2
NFB	7	134	2	2
SUA	4	200	0	0
SUB	5	600	2	1
TOTAL	53		19	11

**Table 1.**

Local authority sampling may be once every year, once every five years or less. In addition many local authorities do not chose sampling times in conjunction with precipitation events. When asked in 1994 many, (64 per cent) were not aware of the seasonal variations in private supply water quality (Clapham and Petrie, 1994). In addition local authorities are often unable to have a flexible sampling regime due to the requirements of the laboratories they use. Therefore, for many authorities, the number of results with very low or zero faecal coliforms per 100 ml. would normally be much greater than encountered during this study.

Results from sampling are often used to assess water quality and give advice on source protection methods and treatment systems. Instances of low faecal coliform results would probably lead to the water being looked on as being of reasonable quality if they were one off samples. The study shows however, the foolishness of such a conclusion.

All but ten samples were positive for *Clostridium perfringens* and all but twenty three positive for *Faecal streptococci*. Neither of these organisms is routinely monitored in private water supplies. Therefore, whereas the faecal coliform standard would lead us to believe the water is of reasonable quality, it can be argued that, in fact, it is contaminated with faecal material and has the potential to contain pathogens.

The results of the study suggest that *Clostridium perfringens* should be routinely included in the suite of indicators. Fewtrell and Kay (1996) have also recommended that *Faecal streptococci* be included in sampling regimes so as to provide useful additional information. Our findings concur with this.

Our findings also lead us to agree with Fewtrell and Kay (1996), in that the quality of small private water supplies should not be considered satisfactory. The results of this study also indicate that when a full understanding of the reasons why contamination takes place, judicious sampling will find a much higher percentage of failures than may normally be found.

## Conclusions

*Cryptosporidium* and *Giardia lamblia* may be found in certain high risk private water supplies at times when contamination is thought to be likely because of recent significant precipitation events.

The incidence of *Cryptosporidium* in the private water supplies tested during the study are significantly correlated with *Faecal streptococci* (correlation coefficient = 0.6783 p 0.001) and *Clostridium perfringens* (correlation coefficient = 0.6268 p 0.001). This does not indicate a causal relationship but can alert local authorities of the possibility of *Cryptosporidium* in private supplies.

## Recommendations

Local authorities should make themselves aware of the possibility and extent of *Cryptosporidium* and *Giardia lamblia* in the private water supplies in their areas. They should also be aware of the indicator organisms likely to correlate with *Cryptosporidium*.

Local authorities need to consider what is the appropriate action to take when they locate private water supplies contaminated with *Cryptosporidium* or *Giardia lamblia*. Action can include advice, informal requests for improvements to the supply and notices requiring improvement under the appropriate legislation (HMSO, 1991a). [6]

Local authorities should make the users of high risk private water supplies aware of the potential problems associated with the ingestion of protozoan parasites.

Local authorities should tailor their sampling programme so that a worse case result is obtained.

Thought should be given to altering the Private Water Supply Regulations 1991 to include the routine monitoring of *Faecal streptococci* and *Clostridium perfringens*.

Sanitary surveys should form an integral part of the assessment of private water supply quality.

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