A Bacterial Examination of Water Supplies in the South East Region

With particular reference to *Clostridia perfringens* as an indicator organism for *Cryptosporidium*.

By
Irene Doyle

Presented in part fulfilment for the degree of Master in Science in Environmental Protection.

Supervised by
Eugene Brady

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ABSTRACT

Traditionally the indicator pathogens used to determine drinking water suitability were Total coliforms and *E. coli*. More recent legislation has introduced *Clostridia perfringens* as an indicator organism for *Cryptosporidium parvum*.

The study investigated the incidence of *C. perfringens* in the South East region in drinking waters, ground waters and surface waters for abstraction. It was found that a number of drinking waters and a large number of ground waters were contaminated with C. perfringens and/or coliforms. Selected locations were analysed for *Cryptosporidium spp.* but none were detected.

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1.0 INTRODUCTION

Water is one of our most precious resources and diseases related to water have plagued mankind since the beginning of time. Waterborne diseases still pose a threat even in today's most technologically advanced societies.

In recent years there has been increasing concern over the role of *Cryptosporidium parvum*, a parasitic protazoan, in waterborne disease with many outbreaks documented, worldwide.

Traditionally the presence of most faecally derived waterborne pathogens in treated drinking water have been indicated to a greater or lesser extent by the presence of *E. coli*. However, the resistance of *C. parvum* to chlorination means that it may be present in the absence of other faecal organisms. (Clancy and Fricker, 1998).

In 1998 the European Union adopted a new drinking water Directive 98/83/EC. This directive was transposed into Irish law in 2000 as S.I. No 439 of 2000. This legislation introduced some changes in the monitoring of drinking water supplies. **One of these changes was the inclusion of *Clostridium perfringens* as an indicator organism for the presence of *Cryptosporidium parvum*. This S.I. will come into force in January 2004.**

In light of this directive, there will be a duty on each Local Authority to formulate a monitoring strategy for *Cryptosporidium*. This is highlighted by Circular Letter L7/98 (Appendix 6), which requests Local Authorities to cover the potential risks associated with *Cryptosporidium spp.* Monitoring in the first instance would be for *Clostridia*, and if detected, both raw and final water would then be analysed for the presence of *Cryptosporidium*.

The purpose of this study was to provide a review of existing water quality with emphasis on *Cl. perfringens* as an indicator organism for *Cryptosporidium parvum* in water supplies in the South East Region, under the authority of the Environmental Protection Agency Regional Laboratory in Kilkenny. Selected Drinking water supplies that test positive for *C. perfringens* would be screened for *Cryptosporidium parvum.* Overall water quality was examined and existing trends identified.

2.0 LITERATURE REVIEW

Legislation is constantly reviewed and updated to ensure the health and safety of the population. The most recent drinking water directive, as detailed below, includes *C.parvum* as a quality monitoring parameter. The reason for this was the increasing concern about *C. parvum* as a waterbourne disease.

2.1 Treatment of Surface Water for Drinking Water

All surface waters abstracted for drinking water contain particles of different size and origin and material, which must be removed efficiently before water distribution. Depending on the raw water quality, particle separation may be accomplished typically by:

- Rapid or slow filtration
- Co-agulation/flocculation/deep bed filtration, or, co-agulation/flocculation/floc separation.
- Settling or flotation and rapid filtration.

Particles, having inorganic or organic origin and whose size is greater than 0.1 µm, are responsible for turbidity and can act as the support and protection for many microorganisms.

There is now, a renewed interest in particle removal efficiencies due to the hygienic problems with the infectious cysts and oocysts of parasites (*Giardia* and *Cryptosporidium*), which are particles in the size range of 3-12µm.

2.2 EU and National Legislative Requirements

EU legislation relating to the protection of environmental waters can be considered on the basis of three categories:

1. Water Quality Objectives
2. Pollution by Dangerous Substances
3. Pollution by other substances affecting water quality.

The aims of EU environmental legislation in relation to water quality objectives are

- To achieve a particular standard for waters intended for a particular use.
- To establish a common monitoring programme and common limits for parameters of analysis throughout the member states.

The Directives relating to Water Quality Objectives can be divided into four categories:

1. Waters intended for Human Consumption
   (i) Waters fit for abstraction
   (ii) Waters fit for drinking
2. Waters for Fish life
3. Waters for Shellfish
4. Bathing Waters

For the purpose of this study only the first category, Waters intended for Human Consumption had relevance.

2.2.1 Waters fit for Abstraction

Council Directives 79/869/EEC concerning the measurement and frequency of sampling and analysis of surface water intended for abstraction and Directive 75/440/EEC concerning the quality of surface water intended for abstraction of drinking water were implemented in Ireland by the European Communities (Quality of Surface Water Intended for Abstraction of Drinking Water) Regulations, 1989.

Council Directive 75/440/EEC lays down requirements regarding the quality of water abstracted for use as drinking water and the degree of treatment necessary prior to its introduction to public supply. Member states must classify existing sources of abstraction water into three categories; A1, A2. And A3. An annex to the directive lists the physical, chemical and microbiological parameters and limits, which define the three categories. Water abstracted for drinking water must be at least of A3 quality.

Council Directive 79/869/EEC supplements directive 75/440/EEC by stipulating methods of measurement and frequency of sampling and analysis. Frequency will increase in accordance with the size of population served.

2.2.2 Water fit for drinking

The European Communities (Quality of Water Intended for Human Consumption) Regulations, 1988, gave formal effect in Irish Law to the EU Drinking Water Directive 80/778/EEC.

At present and up until December 2003 these regulations cover all water for human consumption including water used in the food industry but excluding natural mineral waters or medicinal waters. The regulations set the national quality standards or legal limits for over fifty parameters. These parameters are divided into six groups;

1. Organoleptic
2. Physicochemical
3. Substances undesirable in excessive amounts.
4. Toxic substances
5. Microbiological parameters
6. Minimum Concentrations for Softened Waters.

The minimum frequencies of sampling and analysis, for the respective groups of parameters are also defined.

The parameters are grouped into four categories, on the basis of the frequency with which they are to be analysed.

Table 2.1: Schedules of parameters to be monitored

Minimum monitoring Analysis C1	Current monitoring Analysis C2	Periodic monitoring Analysis C3	Occasional monitoring Analysis C3
Odour Taste Conductivity Total coliforms or Total counts at 22 & 37°C Faecal coliforms	Odour Taste Turbidity Temperature Conductivity pH Nitrates Nitrites Ammonia Total coliforms Faecal coliforms Total counts at 22 & 37°C	Current monitoring (C2) analyses plus other parameters determined by the sanitary authority 'having regard to all factors which may affect the quality of drinking water supplied to users…'	The sanitary authority to determine the parameters according to circumstances, taking an account of all factors, which might have an adverse effect on the quality of drinking water, supplied to consumers.

Note: The frequency of sampling and analysis increases depending on the population served

Those of the European Communities (Quality of Water Intended for Human Consumption) (Amendment) Regulations, 1999, which were broader in their coverage, subsequently supplanted these 1988 regulations.

2.2.3 New Legislation

In November 1998 the EU adopted a new drinking water directive [EU Directive 98/83/EC]. This was radically different from its predecessor [EU Drinking Water Directive 80/778/EEC], and it will entail significant changes in virtually all aspects of implementation including: sample numbers, parameters, parameter classes, and extent of coverage. The full implementation of the Directive is to be accomplished by 25th December 2003.

The key themes of the new directive are:

- greater focus on Human Health
- Flexibility
- Information to consumers

The forty-eight analysis parameters are now grouped into three categories(See Appendix 4):

1.0 Microbiological (Table A)

2.0 Chemical (Table B)

3.0 Indicator (Table C)

The Standards are also in a simpler form in that the twenty-eight parametric values in tables A and B of the directive are 'mandatory', i.e., linked to health, and should not be exceeded. The values in Table C of the directive which are referred to as 'indicator parameters', are linked to quality monitoring.

Monitoring requirements have also been rationalised into two categories:

1.0 Check monitoring

To provide information on the organoleptic and microbiological quality of the water supplied and on the effectiveness of water treatment.

2.0 Audit monitoring

To provide information necessary to determine whether or not all parametric values are being complied with.

Table 2.2: The minimum frequency of sampling

Volume of water distributed or produced each day within a supply zone m^3	Check monitoring – number of samples per year	Audit monitoring- number of samples per year
≥10 ≤100	2	To be determined by the sanitary authority
>100 ≤1 000	4	1
>1 000 ≤10 000	4 +3 for each 1 000 m^3/d and part thereof of the total volume	1 +1 for each 3 300 m^3/d and part thereof of the total volume
>10 000 ≤100 000	4 +3 for each 1 000 m^3/d and part thereof of the total volume	3 +1 for each 10 000 m^3/d and part thereof of the total volume
>100 000	4 +3 for each 1 000 m^3/d and part thereof of the total volume	10 +1 for each 25 000 m^3/d and part thereof of the total volume

One of the changes in this new Directive is the inclusion of *Cl. perfringens* (including spores) as an indicator organism, but includes the note:

> *'This parameter need not be measured unless the water originates from or is influenced by surface water. In the event of non-compliance with this parametric value, the Member State concerned must investigate the supply to ensure that there is no potential danger to human health arising from the presence of pathogenic microorganisms, e.g. Cryptosporidium. Member States must include the results of all such investigations in the reports they must submit under article 13(2).'*

2.3 Cryptosporidia

Despite the fact that the waterborne route of transmission for *Cryptosporidium parvum* was recognised in 1989 many outbreaks have been documented, largely in the United States and United Kingdom (Hayes *et al*., 1989). Rivers, lakes, springs, and ground water have all been implicated as contaminated sources. Reasons for contamination of Drinking water include sewage contamination, contamination by muck or faeces from animals, or faults in the operation procedures during water preparation (Franzen and Müller, 1999). The concern over *C. parvum* is mainly based on two factors. Firstly, the oocyst, the resistant form of the organism, is not destroyed by chlorination. Therefore, in conventional water treatment plants it must be physically removed by coagulation or filtration. Secondly, the detection of most faecally–derived waterborne pathogens in treated drinking water is indicated by the presence of *E. coli*. However, *C. parvum* inherent resistance to chlorine means that it may be present in drinking water in the absence of other faecal organisms.

2.3.1 Clinical Symptoms

The disease caused by *C. parvum* can be particularly severe and common symptoms are diarrhoea, vomiting, abdominal pain, low-grade fever and a general flu-like illness. The severity of the symptoms is influenced by the immune status of the individuals affected. In the immuno-compromised the disease is more severe and because the prognosis is poor, it can result in a high degree of fatalities. There is no antimicrobial treatment for the parasite at present. The current treatment includes supportive care with oral or IV rehydration (Fricker and Clancy, 1998).

2.3.2 Taxonomy

Taxonomically *Cryptosporidium* is a coccidian parasite of the class Apicomplexa. *Cryptosporidium* has a life cycle that involves both asexual and sexual reproductive cycles, which it completes within an individual host. Transmission occurs via an environmentally hardy oocyst excreted in the faeces of the infected host. The infectious dose of *Cryptosporidium* is quite low. Studies by DuPont *et al*, 1995, found that 30 oocysts initiated infection in 20% of individuals exposed and that 132 oocysts caused infection in 50% of exposed healthy volunteers. The infected hosts can then excrete between 10^9 and 10^{10} oocysts per day during disease. (Franzen and Müller. 1999).

At least 21 species of *Cryptosporidium* have been identified. *C. parvum* is the major species responsible for clinical disease in humans and domestic animals and it has been detected in about 80 different mammalian species including cattle, horse, sheep, goat, and pigs.

2.3.3 Expert Group

In March 1989, the Government in the United Kingdom, under the chairmanship of Sir John Badenoch, set up an expert group to advise on the significance for public health of *Cryptosporidium* in water supplies. They set out to examine its occurrence in water, to assess the ability of water treatment processes to protect supplies, and to provide appropriate advice. The resulting 'Badenoch Report' was something of a landmark in water microbiology as it drew attention to the problems of transmission by the water route of this protozoan parasite. The report recognised that it is not yet possible, even with a properly operated plant, to entirely prevent penetration of oocysts into potable water from time to time. Where this happens, many cases of cryptosporidiosis can occur.

The Badenoch report (1990), states that waterborne outbreaks of gastro-enteritis in the United Kingdom in which *Cryptosporidium* or *Giardia* have been implicated have been traced to water treatment plants **which have met all current statutory microbiological and chemical standards.**

2.4 *Clostridium. perfringens*

Clostridium perfringens is thought by some to be the most widely occurring bacterial pathogen, and is without question the most important cause of *Clostridial* disease in domestic animals.

2.4.1 Clinical Symptoms

Food poisoning from *C. perfringens* develops when an individual consumes large numbers of vegetative cells of enterotoxigenic organism. Exposure of the organism to the acidity of the stomach results in death of many of these cells. However, if ingested in sufficient quantities, some cells may survive and pass from the stomach to the intestine where they multiply and then sporulate. It is during sporulation that the enterotoxin is produced. The characteristic symptoms of cramping and diarrhoea start approximately 12 h after ingestion and persist for 12 – 24 h and then spontaneously resolve. *C. perfringens* type A food poisoning ranks as fifth leading cause of death from food poisoning in the USA. The involvement of *C.perfringens* enterotoxin in some cases of sudden infant death syndrome (SIDS) has recently been documented (Rood, 1997).

2.4.2 Taxonomy

Taxonomically, *C. perfringens* is a Gram-positive, spore-forming, non-motile, rod-shaped organism commonly found in soil and in the intestines of humans and other animal species. Although classified as an anaerobe, *C. perfringens* is aerotolerant. Under optimal conditions, generation time for *C. perfringens* is 8-10 min, and growth is accompanied by abundant gas production.

2.5 Indicator organisms.

Direct monitoring of Cryptosporidia and other pathogens is difficult because

(i) their concentrations in source and treated water are usually low and strongly fluctuating and

(ii) analytical procedures are time consuming and have a low recovery efficiency (Hijnen *et al*, 1999).

2.5.1 Traditional Methods

Traditionally, the microbiological quality of drinking water is assessed by monitoring for faecal indicator bacteria. These indicator bacteria usually include total and faecal coliforms (FC) and in European Union legislation also water quality criteria for faecal streptococci and now spores of sulphite-reducing *Clostridia* (SSRC) have been defined (European Union, 1998). SSRC have been included in legislation in the Netherlands since 1984 (Drinking Water Decree, 1984).

Most SSRC present in raw and treated water are of faecal origin (*Clostridium perfringens)* and their presence may be indicative for the presence of persistent pathogens. More recently it has been suggested that SSRC may be used as a surrogate parameter to assess the capacity of water treatment processes to remove (oo)cysts of pathogenic protozoa and viruses (Payment and Franco, 1993).

In the Netherlands, the removal capacity of water treatment for microorganisms was assessed quantitatively by monitoring the concentration of faecal indicator bacteria in the water at various treatment stages (WAM Hijnen *et al.* 1999). The indicator bacteria can easily be determined in the raw water, but after one or more treatment processes the concentration decreases and a sample volume of 100 ml as tested in the routine membrane filtration methods (mf-methods) is too small to assess the actual concentration.
By simultaneously determining the concentration of microorganisms in the source water and in the water after selected treatment stages the decimal elimination capacity (DEC) and the variation in DE values of individual processes and the overall water treatment can be determined. This information could then be used to improve the microbiological safety of drinking water by enhanced microorganism removal in water treatment.

2.5.2 *Clostridia* as an indicator organism

Spores of *Clostridia* can survive in water much longer than the coliform group and are more resistant to disinfection.

In WHO Guidelines it was noted that 'Their presence (SSRC) in disinfected water may indicate deficiencies in treatment and that disinfection- resistant pathogens could have survived treatment'. *Clostridia* are indicative of remote or intermittent contamination.

Hijnen *et al*, (2000), investigated eight full-scale treatment plants in the Netherlands to determine the removal of spores of SSRC. By sampling and processing large volumes of water (1-500 l) SSRC were detected at each stage. This enabled the assessment of the removal efficiency of the units for resistant microbes. The study concluded that SSRC could be used for the identification of the process conditions that cause variation in microorganism removal, which may lead to process optimisation.

2.6 Alternative Water Treatments

2.6.1 Ozonation

Pre-ozonation, ahead of particle removal units, can improve the efficiency significantly and can induce a lower coagulant demand or allow higher rates, e.g. in deep-bed filtration. Ozone gas is added either before or together with the coagulant (Ferric/ Aluminium salts or Cationic polymers) at rather low dosages of 0.5 – 2 mg/l. Microflocculation or ozone-induced particle destabilisation have already been employed (Gottschalk *et al*, 2000). A decrease of 20-90% in turbidity and/or lower particle counts in the filtered water was reported but with a certain degree of variability between samples.

2.6.2 Mixed-Oxidant Disinfection

An alternative water treatment is Mixed-Oxidant Disinfection. The drinking water is disinfected by the on-site production of a mixture of oxidants generated by the electrolysis of a solution of sodium chloride. Electrolysis then converts the brine solution to a mixture of oxidants (free chlorine, chlorine dioxide, hydrogen peroxide, ozone and other short lived oxidants). This technology has been developed over several decades yet the chemical components of this mixture as well as the efficacy of pathogen reduction have not been adequately investigated.

Venczal *et al* (1997) compared the inactivation kinetics of *Cryptosporidium parvum* oocysts and *C. perfringens* spores which were exposed to a 5 mg total oxidant dose of mixed oxidant solution or sodium hypochlorite per litre of oxidant-demand-free (ODF) phosphate buffered water, pH 7.0, at 25°C. Similar inactivation kinetics for *C. parvum* oocysts and *C. perfringens* spores were found by mixed oxidants. This would indicate the potential use of *C. perfringens* spores as an indicator of the disinfection efficacy for *C. parvum*. However, in order to fully establish the reliability of the spores as an indicator, additional studies would be required under a variety of water quality conditions.

3.0 MATERIALS AND METHODS

In this study the main objective undertaken was to assess the water quality, with emphasis on *C. perfringens*, of a number of water supplies in the South East Region. Counties included were Kilkenny, Carlow, North Tipperary, South Tipperary, Laois, Waterford and Wexford. This study was not intended to be an in-depth investigation of each supply, but an overview of the present microbial condition of these supplies.

The assessment of each water source involved four stages;

1.0 Routine Sampling and analysis of water supplies for Total coliforms and *E. coli*

2.0 Non-routine sampling and analysis for *C. perfringens* on all samples.

3.0 Non-Routine analysis for *C. parvum* on selected samples.

4.0 A desk study

The routine sampling and analysis was carried out by the author,EPA staff, and some Local Authority staff, as a part of the annual programme.

Non-routine analysis for *C. perfringens* was added as a parameter for the purposes of this study and undertaken by the author.

Sampling for *Cryptosporidium spp.* was undertaken by the author. Samples were then sent to a contract laboratory ie. City Analysts for specialised analysis.

The desk study was carried out at the office of the EPA, Kilkenny, where surface water intakes were cross-referenced to final water supplies. Water supplies abstracted from groundwater were also cross-referenced.

3.1 Materials

3.1.1 Water

The waters tested were divided into types and their location within the counties assessed and frequency of sampling can be found in the following sections.

(A) Water types

Three water types were routinely analysed in the study

- Surface water intended for abstraction
- Final drinking water
- Ground water

While the main focus of *C. perfringens* in the Drinking Water Directive 98/83/EC is surface water, the inclusion of groundwaters gave a broader indication of the state of the drinking water within the region.

(B) Sampling Frequencies

The three sample types were sampled annually at the following rates:

Drinking waters: In accordance with EC (Quality of Water Intended for Human Consumption) Regulations, 1988.

Surface waters: In accordance with EC (Quality of Surface Water Intended for the Abstraction of Drinking Water) Regulations, 1989.

Ground waters: Twice yearly on discharge and recharge, i.e., autumn and spring.

In the case of the first two, frequency depends on the population served.

(C) Location of waters tested

Seven counties were included as part of this study and the relevant water types and location within the counties can be found in the following figures and tables. The symbols on the respective maps are indicative of water source and actual location or designated code can be found in the table. The codes that are in use in the lab relate to the location of the water within the county. However, for the purpose of this investigation, new codes were issued for presentation of data. A full description of all codes used can be found in the Appendix.

(i) KILKENNY:

Ground	(■)	Surface	(▲)	Drinking	(●)
01500	KKG1	16/D/03/14	KKS1	Radestown	KKD1
Lacken	KKG2	16/C/10/01	KKS2	Bennetsbridge	KKD2
Kennyswell	KKG3	16/M/06/0050	KKS3	Troyswood	KKD3
00400	KKG4	12/B/02/0010	KKS4	Inistoge (raw)	KKD4
02000	KKG5	16/R/05/01	KKS5	Mooncoin	KKD5
00500	KKG6	16/G/05/0040	KKS6	Dunmore	KKD6
01900	KKG7	16/G/05/005	KKS7	Paulstown spring	KKD7
00800	KKG8	16/K/03/01	KKS8	Troyswood (raw)	KKD8
01400	KKG9	14/A/03/02	KKS9	Mooncoin (raw)	KKD9
01300	KKG10	12/B/02/034	KKS10	Radestown (raw)	KKD10
01000	KKG11	12/D/01/07	KKS11		
0700	KKG12	13/C/01/012	KKS12		
Misc	KKG13	16/M/06/0200	KKS13		
00300	KKG14	12/B/01/0012	KKS14		
00100	KKG15				
00200	KKG16				

(ii) CARLOW:

Ground	(■)	Drinking	(●)
01400	CG1	Nurney	CD1
00430	CG2	Tullow	CD2
00550	CG3	Fenagh	CD3
00230	CG4	Bagenalstown	CD4
00100	CG5	Carlow	CD5
00600	CG6	Rathvilly	CD6
00900	CG7	Ticknock	CD7
00800	CG8	Clonmore	CD8
01300	CG9	Bilbao	CD9
01500	CG10	Old Leighlin	CD10
00700	CG11	Leighlin Br	CD11
		Ballon	CD12
		Hacketstown	CD13
		CW160	CD14
		CW080	CD15
		CW010	CD16
		CW050	CD17
		CW170	CD18
		CW100	CD19
		CW040	CD20
		CW060	CD21

(iii) WATERFORD:

Ground (■)		Surface (▲)		Drinking (●)	
01100	WDG1	18/G/06/02	WDS1	Military Rd	WDD1
00500	WDG2	18/G/06/01	WDS2	Tycor	WDD2
01900	WDG3	17/B/02/01	WDS3	Cork Rd	WDD3
00800	WDG4	17/B/04/01	WDS4	Ardkeen	WDD4
01600	WDG5	17/C/02/01	WDS5	Peoples Park	WDD5
01800	WDG6	18/M/04/01	WDS6	Ferrybank	WDD6
02000	WDG7	17/D/03/01	WDS7	Dunmore East	WDD7
01300	WDG8	17/B/03/01	WDS8	Tramore Rd	WDD8
01500	WDG9	18/K/03/01	WDS9		
01200	WDG10				
00200	WDG11				
00100	WDG12				
00400	WDG13				
00700	WDG14				
00600	WDG15				
01000	WDG16				
01700	WDG17				
1400	WDG18				
00900	WDG19				

(iv) WEXFORD

Ground	(■)	Surface	(▲)
01900	WXG1	14/A/03/02	WXS1
00900	WXG2	13/M/01/02	WXS2
01000	WXG3	13/O/01/024	WXS3
00800	WXG4	12/D/07/01	WXS4
01200	WXG5	12/B/02/0012	WXS5
00500	WXG6	13/C/01/0120	WXS6
00200	WXG7	12/B/02/0010	WXS7
00300	WXG8	12/B/02/0012	WXS8
00100	WXG9	12/D/07/01	WXS9
00400	WXG10	14/A/03/02	WXS10
01700	WXG11	13/C/01/0120	WXS11
00600	WXG12	12/B/02/0010	WXS12
02200	WXG13		
01400	WXG14		
01500	WXG15		
02000	WXG16		
01800	WXG17		
00700	WXG18		
01600	WXG19		
Borrisokane	WXG20		

(V) OFFALY

Ground	(■)
Clonaslee	OYG1
Rhodia	OYG2
Rahan	OYG3
Walsh island	OYG4
Ferbane	OYG5
Banagher	OYG6
Geashill	OYG7
Cloreen	OYG8
Knocks	OYG9
Dunkerrin	OYG10
3	OYG11
4	OYG12
10	OYG13
11	OYG14
13	OYG15
19	OYG16
21	OYG17
23	OYG18
27	OYG19
28	OYG20
29	OYG21

(vi) LAOIS

Ground (■)		Surface (▲)		Drinking (●)	
1	LSG1	14/O/01 /005	LSS1	Ales	LSD1
3	LSG2			Bally buggy	LSD2
5	LSG3			Ballylynan	LSD3
13	LSG4			Clonaslee	LSD4
14	LSG5			Donaghmore	LSD5
19	LSG6			Dublin rd	LSD6
22	LSG7			Emo	LSD7
23	LSG8			Erril	LSD8
28	LSG9			Graiguecullen	LSD9
37	LSG10			Irishtown	LSD10
39	LSG11			Ironmills	LSD11
40	LSG12			Meelick	LSD12
Abbeyleix	LSG13			Misc	LSD13
Farmoyle	LSG14			Mountmellick	LSD14
Donaghmore	LSG15			Mountrath	LSD15
Durrow	LSG16			Mountrath rd	LSD16
Edenderry	LSG17			Portalington	LSD17
				R. Corbally	LSD18
				Rathdowney	LSD19
				Rosenalis	LSD20
				Shanbeg	LSD21
				The Strand	LSD22
				The Swan	LSD23
				Port. Timahoe	LSD24
				Timahoe	LSD25
				Vicarstown	LSD26
				Ballinakill	LSD27
				Durrow	LSD28
				Stradbally	LSD29

(vii) TIPPERARY

Surface (▲)		Drinking (●)	
25/K/04/005	TNS1	Borrisokane	TND1
		Borrisoleigh	TND2
		Bouladuff	TND3
		Cloughjordan	TND4
		Glashahulla raw	TND5
		Glenbeha	TND6
		Glenbeha raw	TND7
		Kilcommon	TND8
		Nenagh	TND9
		Newport	TND10
		Roscrea	TND11
		Templemore	TND12
		Thurles	TND13
		Water tower	TND14
		T. Toberaloo	TND15

Tipperary South

Ground (■)				Surface (▲)		Drinking (●)			
02200	TSG1	01010	TSG16	16/P/03/02	TSS1	Graingemockler	TSD1	Clonmel (Irishtown)	TSD16
00810	TSG2	00815	TSG17	16/C/03/005	TSS2	Clonmel	TSD2	Clogheen	TSD17
02000	TSG3	01300	TSG18	16/G/05/05	TSS3	Carrick-on-Suir	TSD3	Burncourt	TSD18
00600	TSG4	01200	TSG19	16/P/03/01	TSS4	Carribeg	TSD4	Bansha	TSD19
01900	TSG5	01100	TSG20	16/G/05/004	TSS5	Ahenny	TSD5	Tipp UDC	TSD20
00900	TSG6	00200	TSG21	16/D/03/14	TSS6	Coalbrook	TSD6	Ballincurry	TSD21
00100	TSG7	01800	TSG22	16/G/02/05	TSS7	Faugheen	TSD7	Emily/Lattin	TSD22
00500	TSG8	01700	TSG23			Killenaule	TSD8	Glengar	TSD23
01400	TSG9	01000	TSG24			Galtee regional	TSD9	Cappawhite	TSD24
00700	TSG10	00812	TSG25			Fethard	TSD10	Dundrum	TSD25
00400	TSG11					Kilcash	TSD11	Boherlahan	TSD26
01600	TSG12					Cahir	TSD12	Inchirourke	TSD27
00800	TSG13					Ballinvar	TSD13	Hollyford	TSD28
00814	TSG14					Comons	TSD14	Tullahea	TSD29
00300	TSG15					Clonmel (Davis rd)	TSD15	Mullinahone	TSD30

3.1.2 Chemicals:

The chemicals used during this project were sourced from a number of companies including Technopath, Oxoid and Brownes.

3.2 Methods

3.2.1 Field analysis

Field analysis included the parameters that would change on transport:

- Temperature
- Dissolved oxygen for surface waters
- Residual and total chlorine for drinking water

The methods and sample preparation can be found in Appendix (3).

3.2.2 Routine Laboratory analysis

Laboratory analysis included all the parameters that are required by current legislation for the three water types (Table 3.1).

Coliforms were quantified using the 'Colilert' method. Colilert uses a patented Defined Substrate Technology (DST) to simultaneously detect and confirm total coliforms and *E. coli*. As coliforms grow in Colilert, they use β-galactosidase to metabolise ONPG nutrient indicator and change it from clear to yellow. *E. coli* uses β-glucuronidase to metabolise MUG nutrient indicator and create flourescence.

The Defined SubstrateTechnology reagent /sample mixture were poured into Quanti-Trays, sealed and incubated at 37°C for 24h. The number of yellow and/or flourescent wells were counted. Reference to the MPN Table provided determined the Most Probable Number of total coilforms and *E. coli*.

Table 3.1: Routine Analysis Parameters for Surface, Drinking and Ground Water:

Parameter	Surface Water	Ground Water	Drinking Water
Odour		X	X
Taste		X	X
Conductivity	X	X	X
Total Coliforms	X	X	X
Faecal Coliforms	X	X	X
Free Residual Chlorine			X
Total Residual Chlorine			X
Turbidity		X	X
Temperature	X	X	X
pH	X	X	X
Total bacteria @ 22oC			X
Total bacteria @ 37oC			X
Nitrite	X	X	X
Nitrate	X	X	X
Ammonia	X	X	X
Chloride	X	X	X
o-Phosphate	X	X	X
Sulphate		X	X
Sodium		X	X
Potassium		X	X
Magnesium		X	X
Calcium Hardness		X	X
Alkalinity		X	X
TOC		X	X
Colour	X	X	X
Metals		X	X
Fluoride			X

A comprehensive detail of the methods involved for each parameter can be found in Appendix (1).

3.2.3 Non-Routine laboratory Analysis- detection of *C. perfringens* and *Cryptosporidia*

(A) Sampling and analysis for *C. perfringens*

The method for enumeration of *C. perfringens,* as stated in Directive 98/83/EC, is membrane filtration of 100ml of sample for drinking and ground waters and an appropriate aliquot diluted to 100ml using ¼ strength Ringers solution for surface waters, followed by anaerobic incubation of the membrane on m-CP agar at 44 ±1°C for 21 ±3h.

However the directive also states in Annex iii

> *'member stated may use alternative methods, providing the provisions of Article 7 (5) are met.'*

The method employed for this study was membrane filtration using the volumes detailed above, followed by anaerobic incubation of the membrane on Tryptose Sulphite Cycloserine Agar (TSC agar) at 37 ± 0.5°C for 48h. *C. perfringens* colonies may be seen as large, black colonies. (Ref Method: 7.10 in the Report on Public Health and Medical Subjects No71 – Part1)

Presumptive confirmation was performed by a subculture of black colonies to Crossley Milk Medium and anaerobic incubation at 37 ±0.5°C for 24h. The reaction of *C. perfringens* included acid production and the formation of a characteristic 'stormy' clot.

The presence of *C. perfringens* in the sample was then confirmed by Gram stain analysis

(B) Sampling and Analysis for *Cryptosporidia*

Sampling and analysis for *Cryptosporidium spp.* is very labour intensive and large volumes of water must be analysed in a specialist laboratory. Due to the low infective dose for *Cryptosporidia* and the low numbers isolated from environmental samples, large volumes of water (>100l) need to be sampled and examined. (Byrne,). The procedure for the detection of protozoan parasites in water can be divided into three basic sections:

- Sampling
- Concentration
- Identification

Sampling was the only stage carried out by the author. A cartridge filtration technique was used. Water was passed through a pleated membrane filter at a recommended flow rate of 1.5l/min for a volume of approx. 300l. The cartridge was then removed from the housing and suitably bagged and sent to a contract lab ie, City Analysts Limited, for concentration and identification

Concentration of the sample involved teasing apart the filter and elution of the concentrated material by washing with a detergent solution. The eluent was then concentrated by centrifugation. Clarification was by density flotation on a percoll-sucrose solution of a specific gravity. The oocysts float on top of the sucrose layer.

Identification was determined by immunoflourescence staining and microscopy.

Fig. 3.1 : Cryptosporidium sampling rig in situ in Troyswood Treatment Plant. Picture shows from left to
right: Flow restrictor and meter, cartridge housing, Hose connected to Raw Supply Tap.

Fig. 3.2: Cryptosporidium rig in situ in Clonmel Water Treatment Plant. Picture shows from left to right: Pump, Cartridge housing, Battery, Flow restrictor and meter. Hose is in Raw Water sump.

4.0 RESULTS

4.1 Routine sampling for Coliforms and Non-routine sampling for Clostridia

The detection of coliforms is an indicator of water quality etc… as previously stated and any link between it and clostridium presence in the absence of coliforms was determined for seven counties for different water types relevant to the county (Fig.s 4.1.1-4.1.8 and Tables 4.1 and 4.2).

Where no coliforms or clostridia were detected in the water sample, the location sample was not plotted.

The water samples were independent of time but location specific.

4.1.1 Kilkenny

The drinking water sample locations with high levels were in fact raw untreated samples.

4.1.2 Carlow

It is interesting to note the presence of Clostridia in the absence of total coliforms or *E. coli.* in three of the drinking water samples. Clostridia can survive longer than coliforms.

4.1.3 Waterford

The ground water sample WDG3 is badly contaminated as indicated by a number of parameters. This sample is untreated. High incidences of Total coliforms in surface waters are to be expected.

4.1.4 Wexford

Surface water sample WXS6, which has high bacterial counts is a proposed supply and not used at the time of this report.

4.1.5 Offaly

High levels of total coliforms in untreated ground water is not uncommon due to farming influences.

4.1.6 Laois

Drinking water sample LSD21 gave cause for concern as repeated testing resulted in high levels of Clostridia and coliforms.

4.1.7 Tipperary North

Sample TND5 is a raw untreated sample and did not give rise for concern. TND7 and TND14 were noted for further investigation.

4.1.8 Tipperary South

Drinking water sample TSD15 was selected for Cryptospordium testing because this is a municipal supply in Clonmel and had high levels of Clostridia.

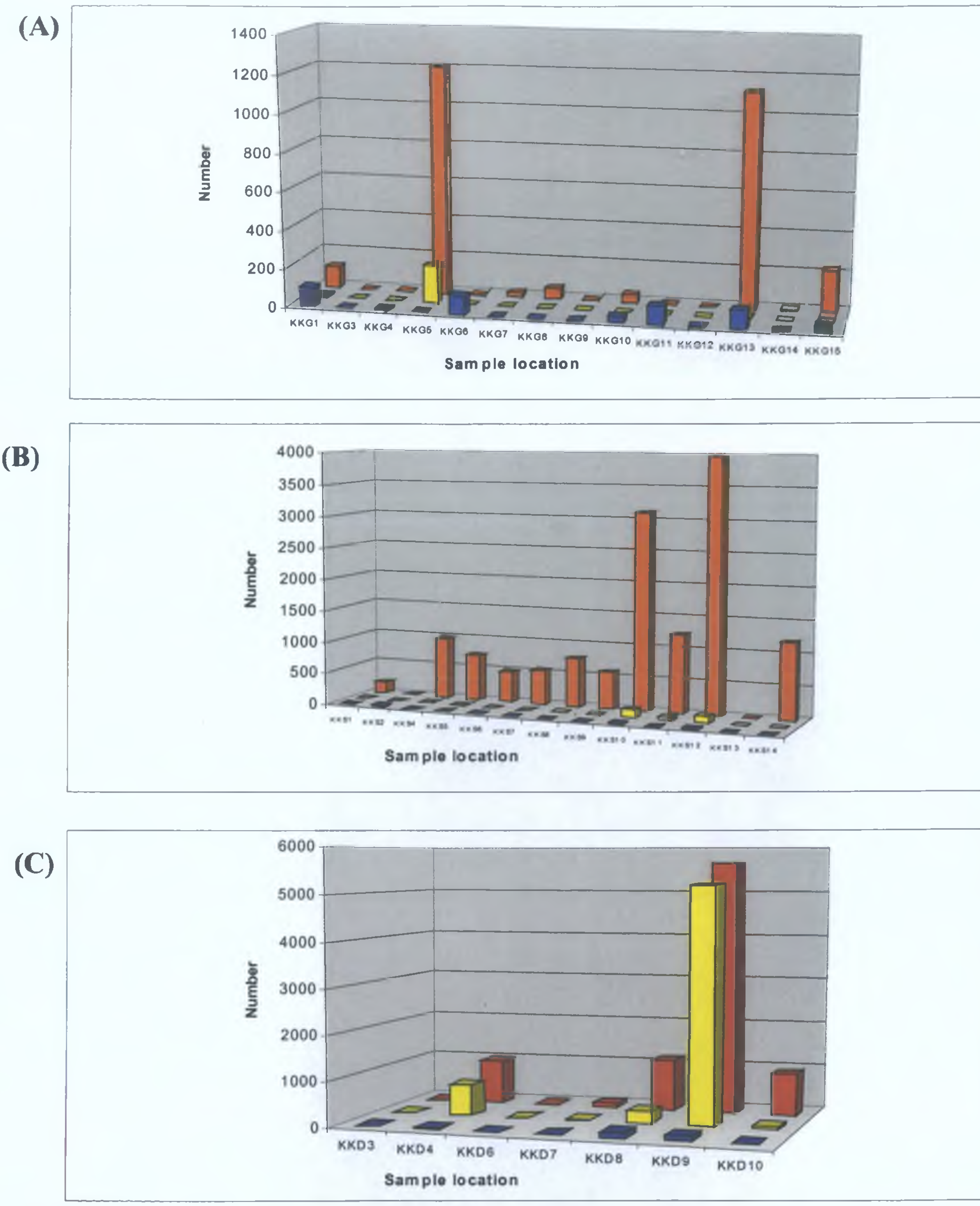
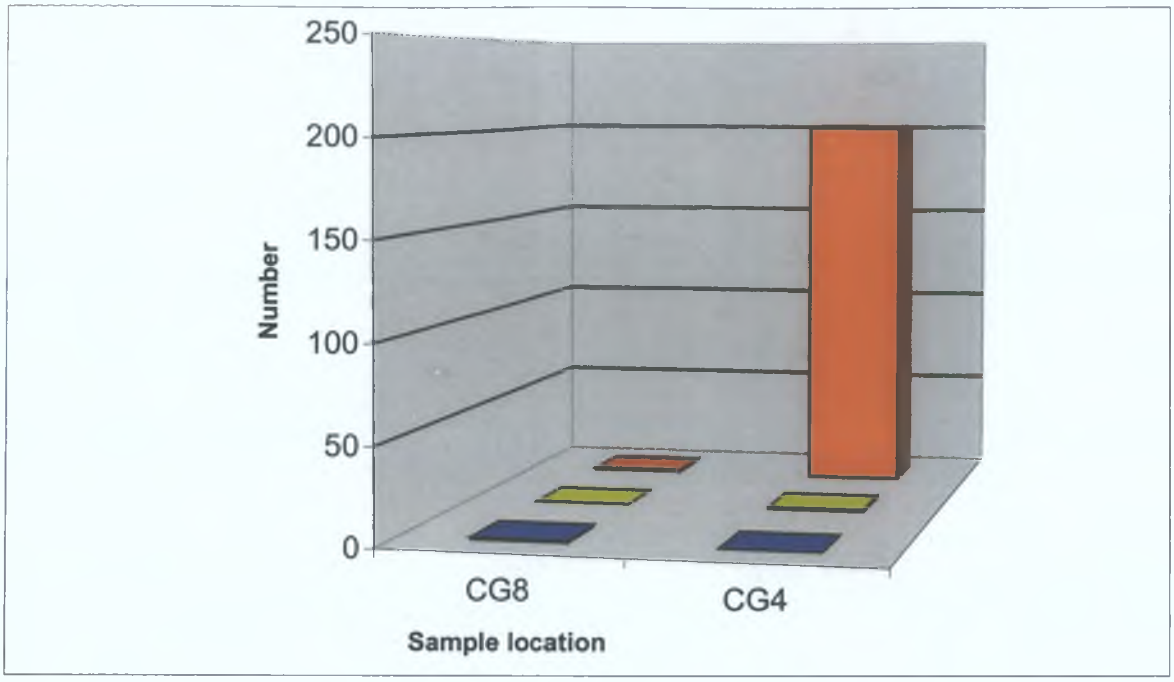


Fig. 4.1.1: Coliform and clostridium counts for County Kilkenny for Ground water (A), Surface water (B) and Drinking water (C).

Legends: (■) = Total coliforms; (■) = Faecal coliforms; and (■) = Clostridia.

(A)



(B)

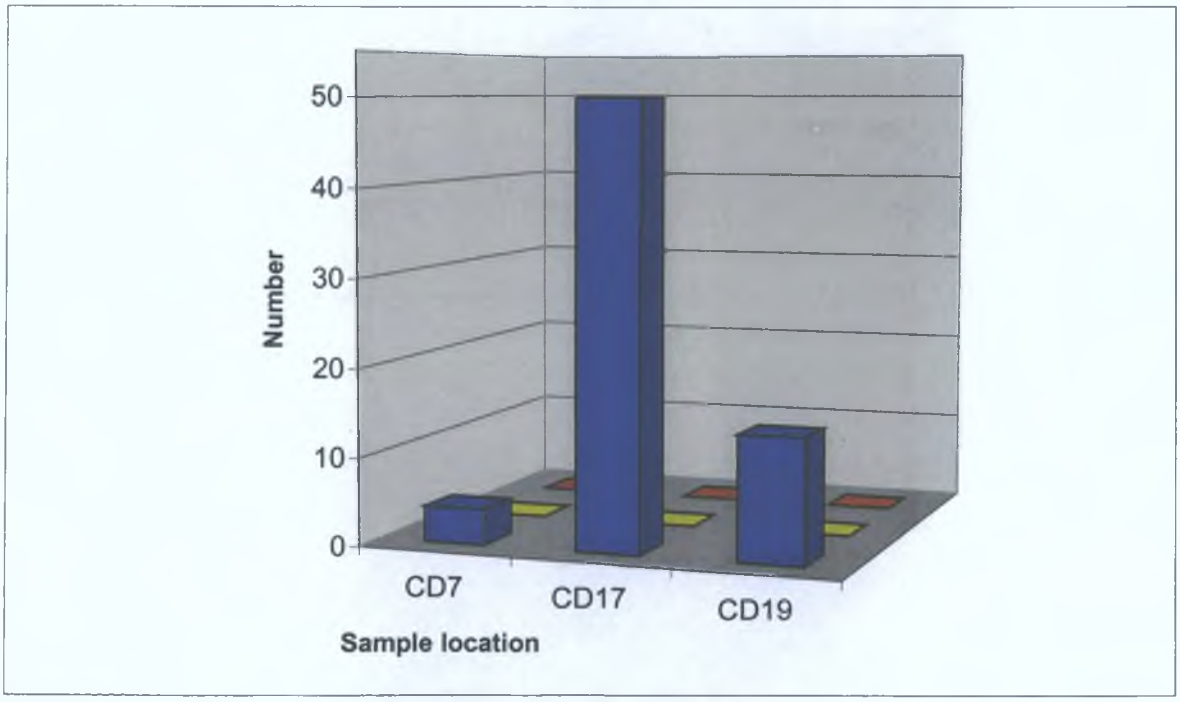
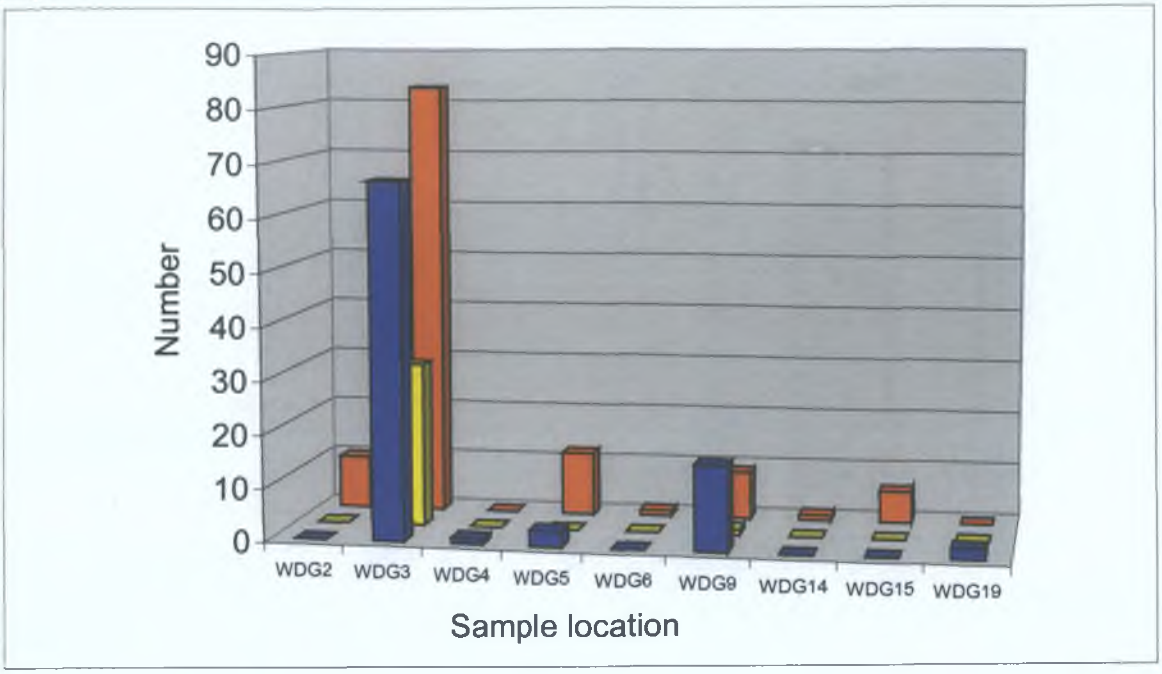


Fig. 4.1.2: Coliform and clostridium counts for County Carlow for Ground water (A) and Drinking water (C).

Legends: (■) = Total coliforms; (■) = Faecal coliforms; and (■) = Clostridia.

(A)



(B)

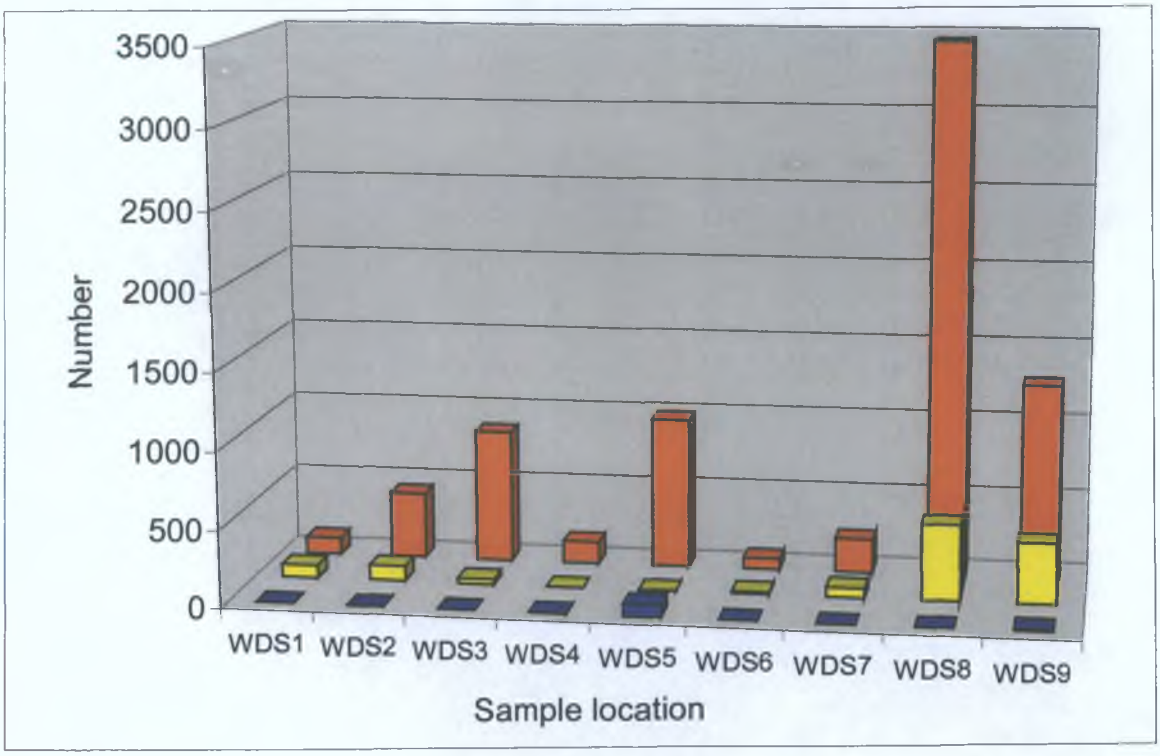
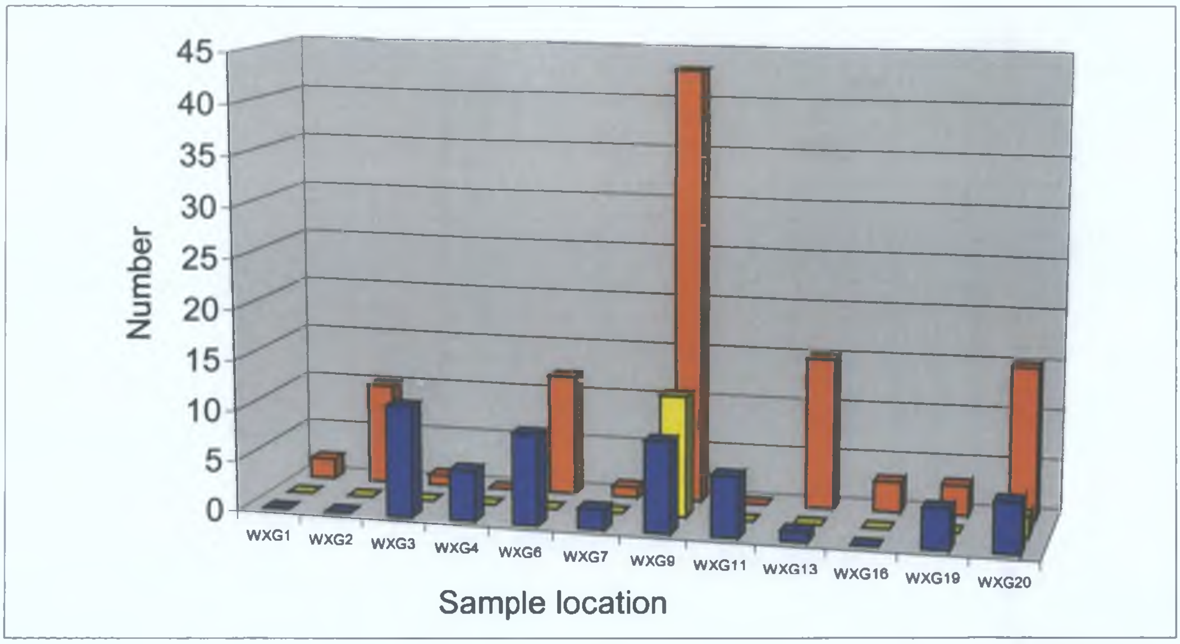


Fig. 4.1.3: Coliform and clostridium counts for County Waterford for Ground water (A) and Surface water (B).

Legends: (■) = Total coliforms; (■) = Faecal coliforms; and (■) = Clostridia.

(A)



(B)

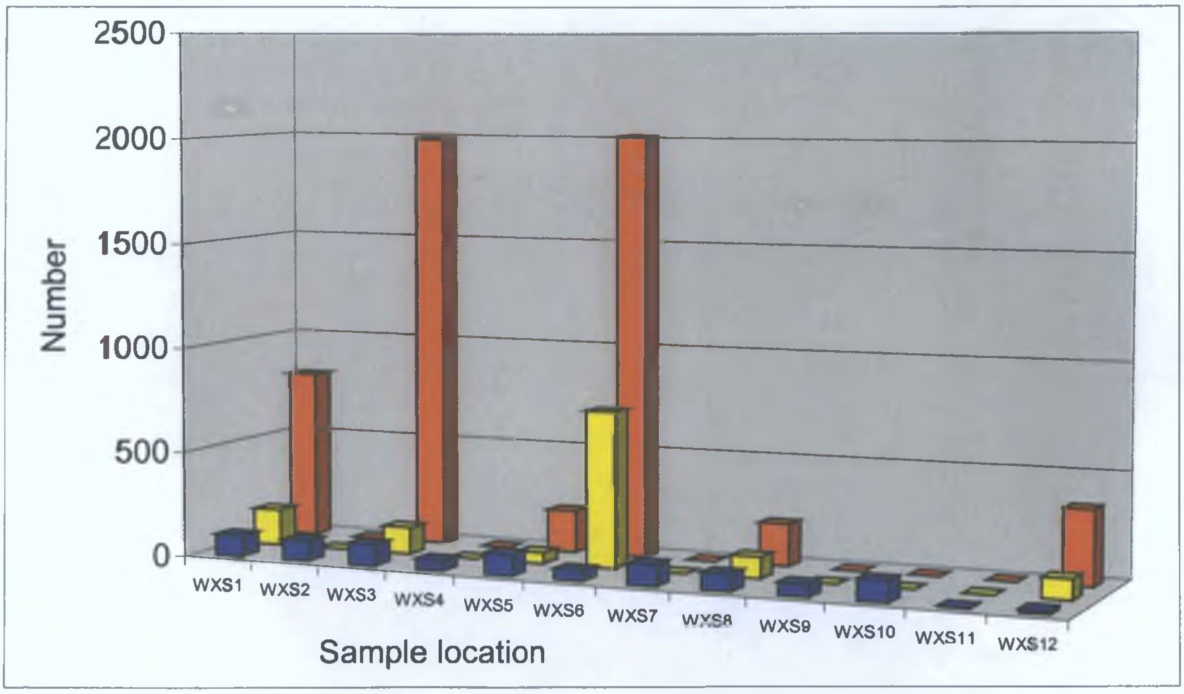


Fig. 4.1.4: Coliform and clostridium counts for County Wexford for Ground water (A) and Surface water (B).

Legends: (■) = Total coliforms; (■) = Faecal coliforms; and (■) = Clostridia.

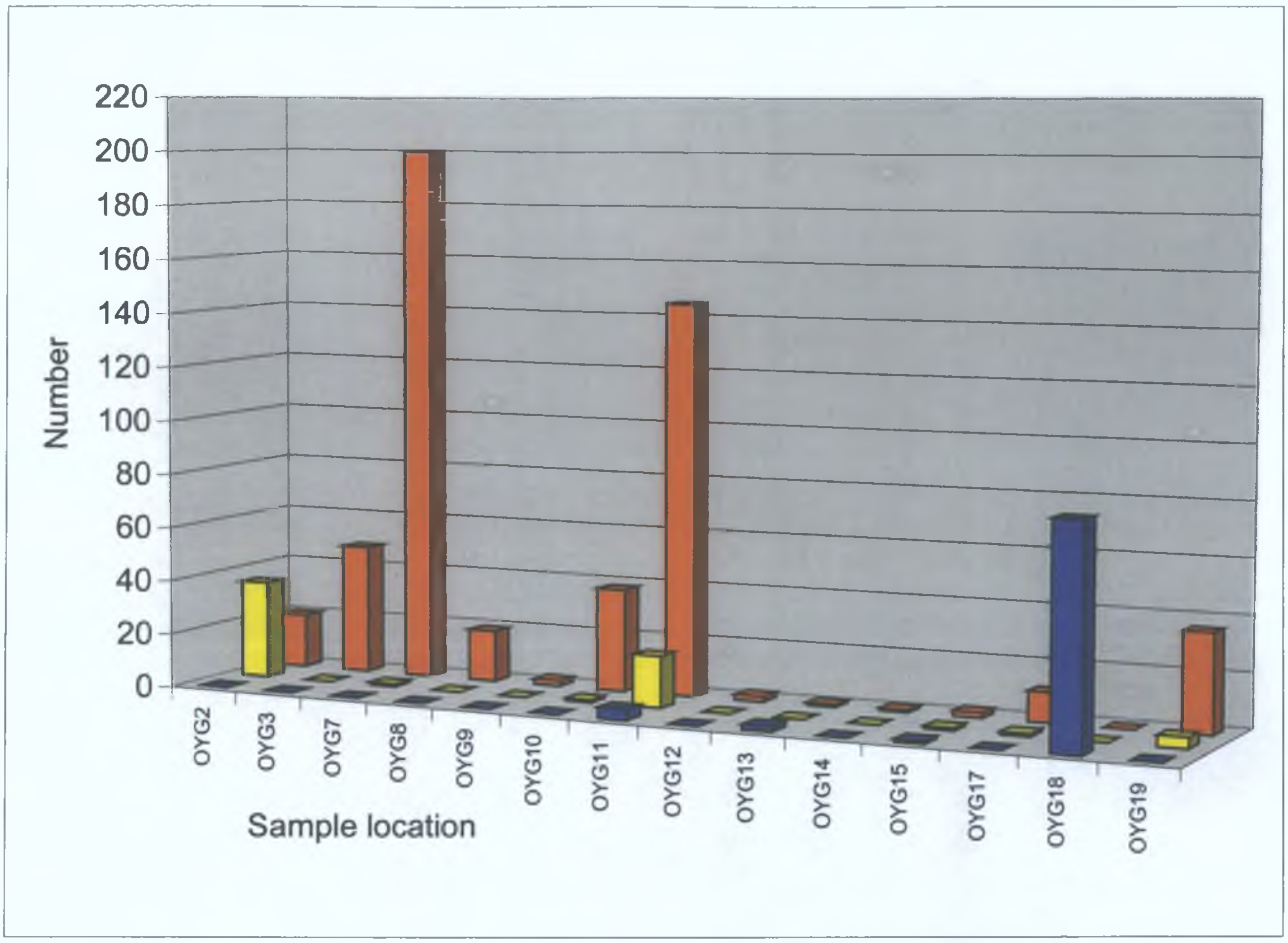
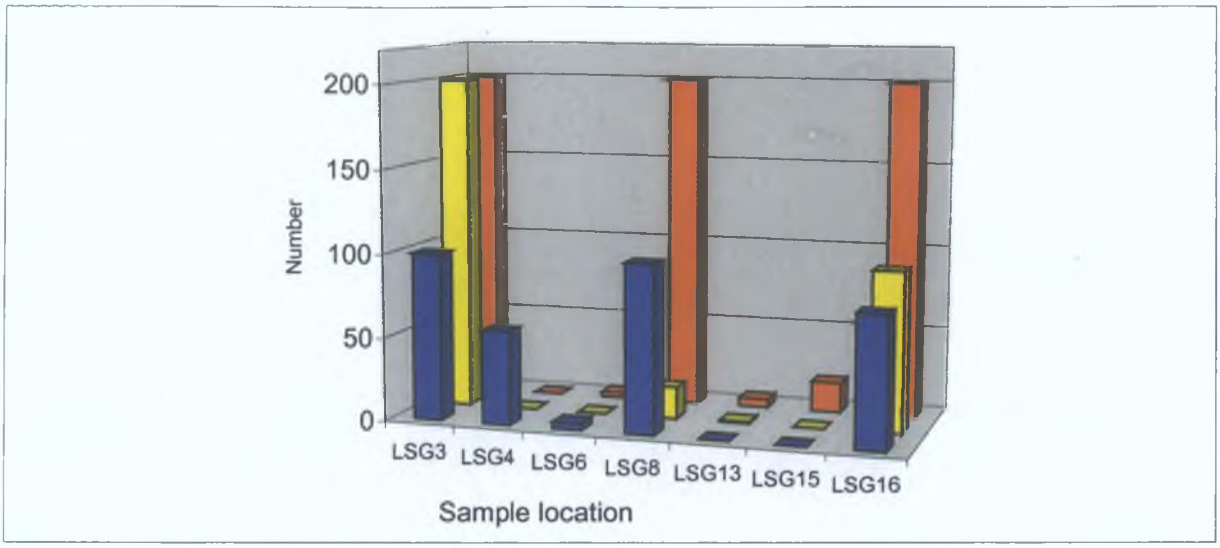


Fig. 4.1.5: Coliform and clostridium counts for County Offaly for Ground water.

Legends: (■) = Total coliforms; (■) = Faecal coliforms; and (■) = Clostridia.

(A)



(B)

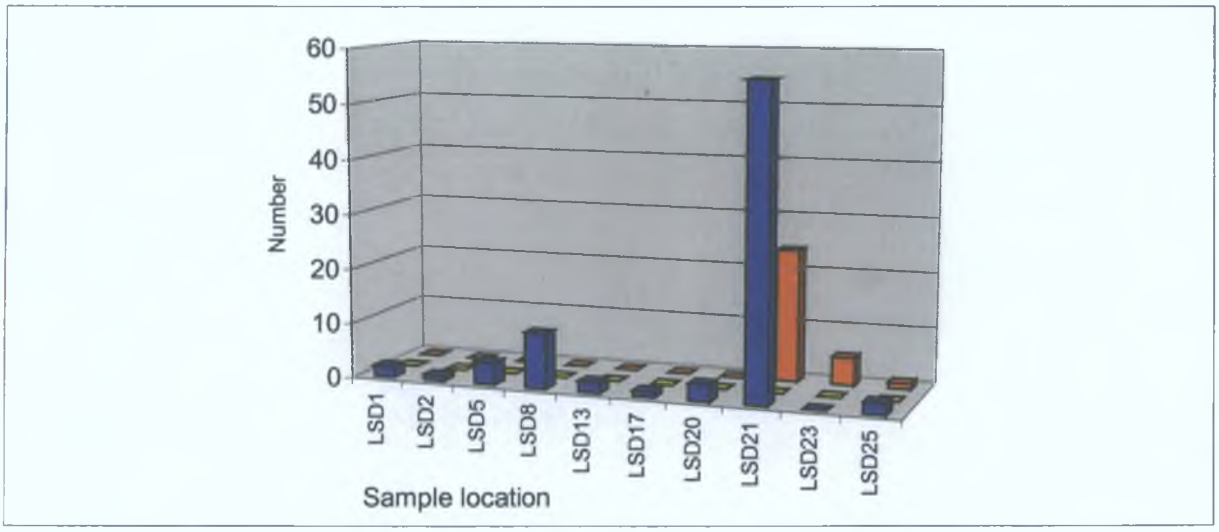


Fig. 4.1.6: Coliform and clostridium counts for County Laois for Ground water (A) and Drinking water (B).

Legends: (■) = Total coliforms; (■) = Faecal coliforms; and (■) = Clostridia.

Table 4.1: Surface water coliform and clostridium counts for County Laois

Sample location	Clostridia	Total Coliforms	Faecal Coliforms
LSS1	100	1986	344

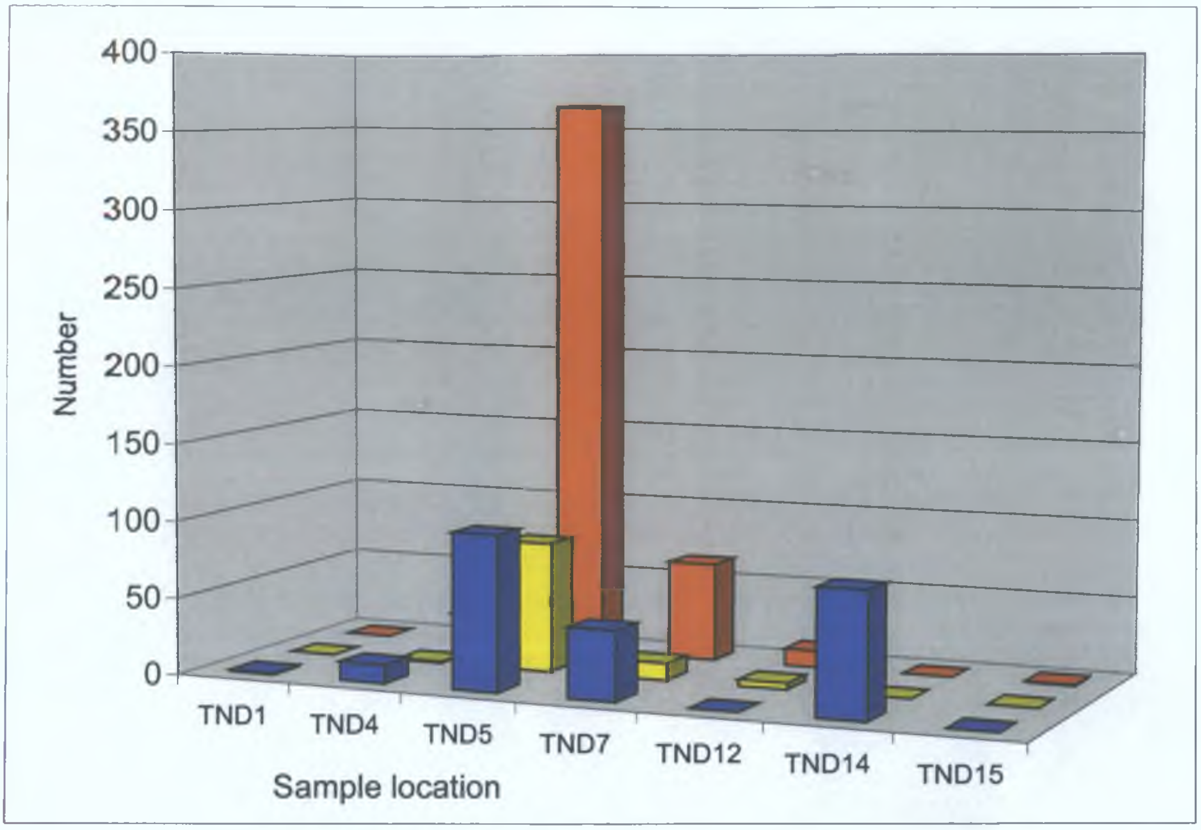


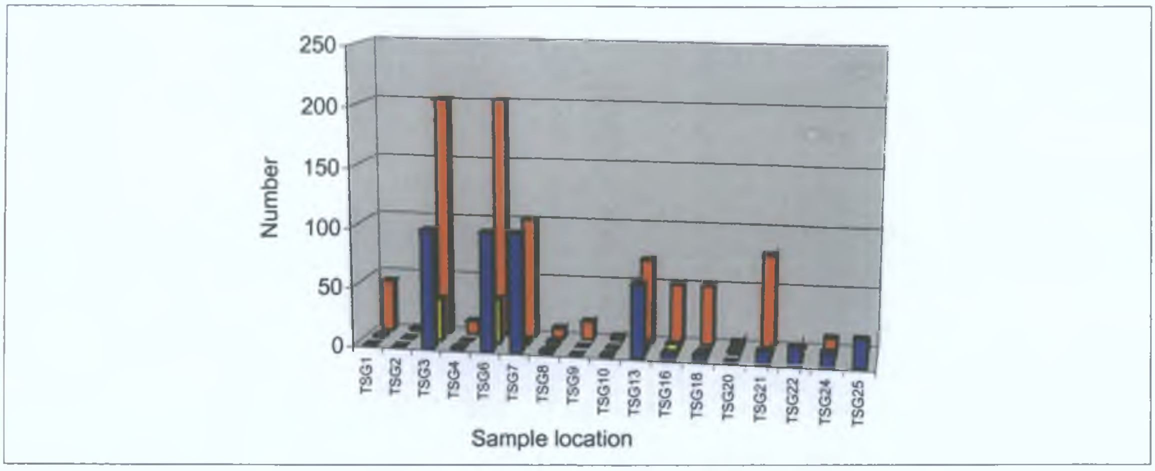
Fig. 4.1.7: Coliform and clostridium counts for Tipperary North for Drinking water.

Legends: Legends: (■) = Total coliforms; (■) = Faecal coliforms; and (■) = Clostridia.

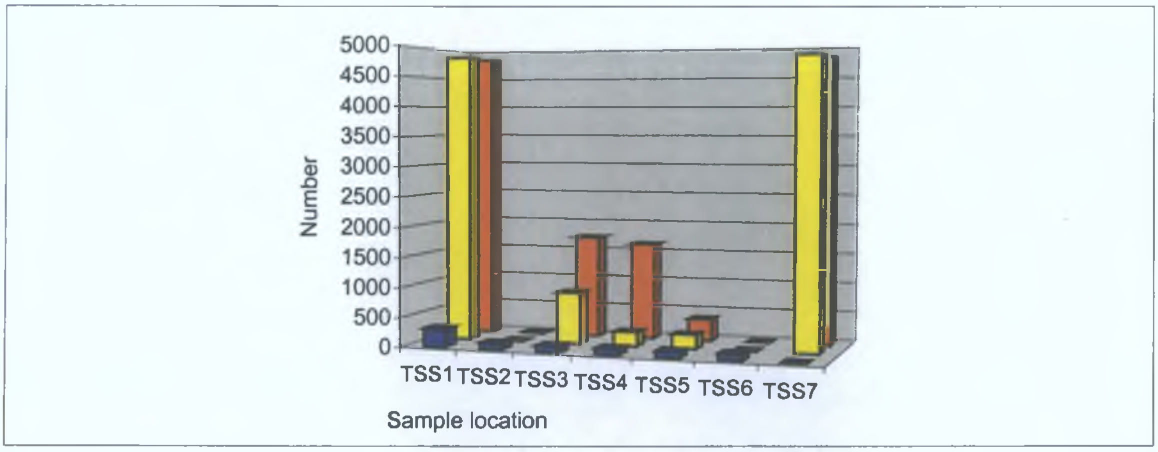
Table 4.2: Surface water coliform and clostridium counts for Tipperary North

Sample location	Clostridia	Faecal Coliforms	Total Coliforms
TNS1	2500	0	0

(A)



(B)



(C)

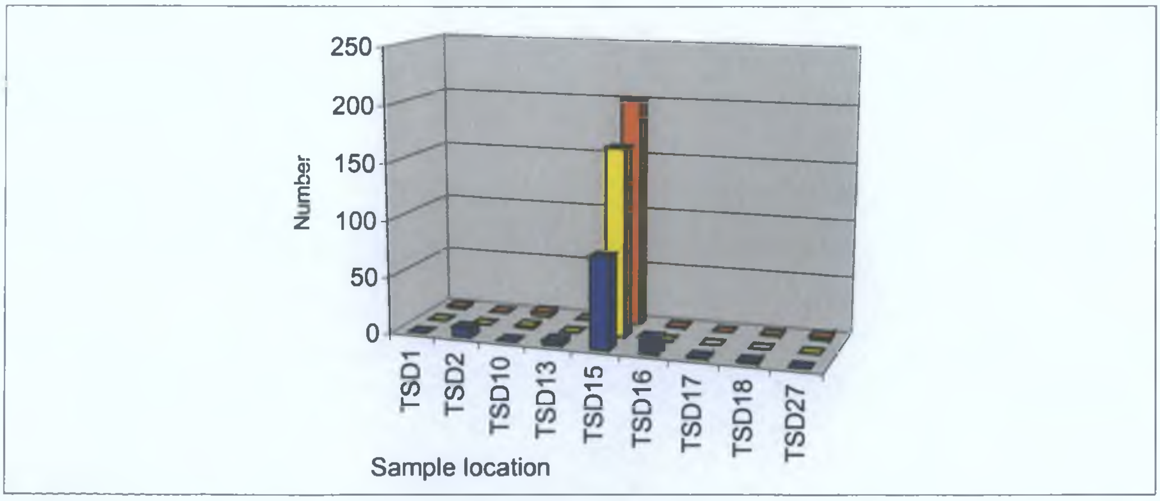


Fig. 4.1.8: Coliform and clostridium counts for Tipperary South for Ground water (A), Surface water (B) and Drinking water (C).

Legends: (■) = Total coliforms; (■) = Faecal coliforms; and (■) = Clostridia

(A) (B)

Fig. 4.2.1: Illustration of presumptive confirmation of *C. perfringens* on TSC agar after 48h anaerobic growth from a Raw (A) and a Final (B) Drinking Water sample from Clonmel (Davis Rd. Supply)

Fig. 4.2.2 : Illustration of *Clostridia perfringens* gram stain from plate (B) above.

4.2 Non-Routine Cryptosporidium spp. Analysis

Eight sample locations were selected for *Cryptosporidium parvum* analysis. These locations were selected based on positive Clostridia results.

1. Troyswood supply in Kilkenny City – Both Raw and Final
2. Davis Road supply, Clonmel – Both Raw and Final
3. Rosenallis/Shanbeg, Laois
4. Donaghmore, Laois
5. Upperforest, Laois
6. Ballybuggy, Laois
7. Errill, Laois
8. Timahoe, Laois

Two of the locations selected were large municipal supplies employing different treatment systems. In the Troyswood plant in Kilkenny, flocculation/coagulation and rapid filtration methods are currently employed. The more traditional slow sand filtration is used in Clonmel. The remainder of the locations were at smaller sites in Laois and were identifed by the Local Authority Engineer based solely on the Clostridia results from this study.

Samples were collected at the recommended rate of 1.5L/min. (City Analysts). Recommended sample volumes for raw water are a minimum of 50-100L and for treated water a minimum of 50-100L but where possible up to 1000L. Actual sample volumes are detailed in table 4.2. (see Appendix 5)

Table 4.3 Results for Cryptosporidia and Giardia Analysis

Sample Location	Code	Volume Sampled (L)	No. Cryptosporidial Oocysts detected/L	No. of Giardial Cysts Detected/L
Troyswood Raw	KKD8	315	0	0
Troyswood Final	KKD3	405	0	0
Clonmel Raw	TSS1	136	0	0
Clonmel Final	TSD15	146	0	0
Rosenallis/ Shanbeg		256	0	0
Donaghmore		271	0	0
Upper Forest		176	0	0
Ballybuggy		430	0	0
Errill		376	0	0
Timahoe		235	0	0

Historical data for the Troyswood samples have shown the presence of giardial cysts in both the raw and treated samples.

5.0 DISCUSSION

5.1 Drinking Water

One hundred and fifty three final drinking water samples were tested. Seventy eight percent were free of bacterial contamination. This gives rise to great concern over the twenty two per cent of samples that were contaminated to a greater or lesser extent. The breakdown of contamination was as follows:

Clostridia:	15%
Total coliforms:	11%
Total Coliforms + Faecal Coliforms:	4%

Repeat sampling confirmed contamination on some locations. The sanitary authorities are aware of this and make continuing efforts to remediate quality problems. Where samples tested positive for Total Coliforms only, this is an indication of intrusion from soil.

5.2 Surface Water for abstraction

Total and faecal coliforms and *C. prefringens* were found in all but one surface water sample. As expected the larger low lying rivers had higher levels of contamination. Agricultural practices, industrial discharges and sewage discharges all contribute to likely sources of waterbourne oocysts and cysts.

Periods of heavy rainfall may also increase the risk of run-off of oocysts into watercourses. Catchment control and improvements in agricultural practices can play a major part in reducing these risks and preventing the contamination of water supplies.

5.3 Ground Water

While ground water is not included in Directive 98/83/EC for Cryptosporidium or Clostridia testing, it was included in this study. Ground water accounts for up to 15 per cent of total water supplied by local authorities. One quarter of the water abstracted for public and private use is from groundwater. (McGarrigle *et al*, 2002).

Some coliforms are naturally occuring in soil and are not of faecal origin. However the incidence of faecal coliforms and clostridia in groundwater in all of the counties tested highlights the importance of disinfection of groundwater before consumption.

Source location and construction are also important considerations to protect from poor control of animal wastes and septic tanks.

6.0 CONCLUSION

The purpose of this study was to examine Drinking Water supplies in the South East Region for *Clostridium perfringens* and if detected to screen selected water supplies for *Cryptosporidium sp.*

Eight of the Drinking Water supplies that tested positive for *Clostridium perfringens* were selected for screening for *Cryptosporidium sp.* No *Cryptosporidium spp.* were detected.

It is difficult to draw any correlation from this study between *C. perfringens* and *C. parvum.* The interpretation of negative results deserves some consideration. It is important to look at the recovery efficiency of the methods employed for sampling and analysis. Continuing advances in sampling and analysis techniques will improve recovery efficiency. Another important factor to consider is the frequency of sampling.

While indications from this study are that *C. perfringens* is not a good indicator for the presence *Cryptosporidium sp,* ten percent of the Drinking Waters analysed tested positive for *C. perfringens* in the absence of Total Coliforms and *E. coli.* This alone gives rise for concern and indicates the need for investigation.

The overall sampling strategy should be reviewed for each water treatment plant, taking into account the catchment area characteristics and the nature of the water treatment available.

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APPENDICES

Appendix 1 Table of Parameter methods

Parameter	Units	Method
Odour		
Taste		
Conductivity	µS/cm	WTW LF538
Total Coliforms	No./100ml	Colilert
Faecal Coliforms	No./100ml	Colilert
Free Residual Chlorine		Hach
Total Residual Chlorine		Hach
Turbidity	NTU	Hach Turbidimeter
Temperature	°C	Digi probe
pH		WTW pH 539
Total bacteria @ 22oC	No./1ml	MF
Total bacteria @ 37oC	No./1ml	MF
Nitrite	mg/l N	Konelab30
Nitrate	mg/l N	Konelab30
Ammonia	mg/l N	Konelab30
Chloride	mg/l Cl	Konelab30
o-Phosphate	mg/l P	Konelab30
Sulphate	mg/l SO_4	Dionex
Sodium	mg/l Na	Dionex
Potassium	mg/l K	Dionex
Magnesium	mg/l Mg	Dionex
Calcium Hardness	mg/l $CaCO_3$	Dionex
Alkalinity	mg/l $CaCO_3$	Titration
TOC	mg/l C	Dohrmann DC190
Colour	mg/l PtCo	Nessleriser
Metals	mg/l	ICP
Fluoride		Dionex

Appendix 2. Field Methods and Sample Handling.

Methods

1.0 Dissolved Oxygen : WTW meter LF197

2.0 Temperature: WTW meter LF197

3.0 Residual and Total Chlorine: Hach portable meter.

Sample Handling

All samples are refridgerated on sampling and analysed within 30h.

Appendix 3: Results for Coliforms and Clostridia

Drinking Waters

County	Sample type	Location	Clostridia	Total Coli	Faecal Coli
Carlow					
	Drinking Water	Nurney	0	0	0
	Drinking Water	Tullow	0	0	0
	Drinking Water	Fenagh	0	0	0
	Drinking Water	Bagenalstown	0	0	0
	Drinking Water	Carlow	0	0	0
	Drinking Water	Rathvilly	0	0	0
	Drinking Water	Ticknock	4	0	0
	Drinking Water	Clonmore	0	0	0
	Drinking Water	Bilbao	0	0	0
	Drinking Water	Old Leighlin	0	0	0
	Drinking Water	Tullow	0	0	0
	Drinking Water	Rathvilly	0	0	0
	Drinking Water	Carlow	0	0	0
	Drinking Water	Leighlin Br	0	0	0
	Drinking Water	Bagenalstown	0	0	0
	Drinking Water	CW160	0	0	0
	Drinking Water	Hacketstown	0	0	0
	Drinking Water	CW080	0	0	0
	Drinking Water	Ballon	0	0	0
	Drinking Water	CW010	0	0	0
	Drinking Water	CW050	50	0	0
	Drinking Water	CW170	0	0	0
	Drinking Water	CW100	14	0	0
	Drinking Water	CW040	0	0	0
	Drinking Water	CW060	0	0	0
Kilkenny					
	Drinking Water	Radestown	0	0	0
	Drinking Water	Bennettsbridge	0	0	0
	Drinking Water	Troyswood Raw	226	152	45
	Drinking Water	Inistioge Raw	27	980	687
	Drinking Water	Troyswood	0	0	0
	Drinking Water	Mooncoin	0	0	0
	Drinking Water	Dunmore	0	9	0
	Drinking Water	Mooncoin Raw	100	5654	5199
	Drinking Water	Paulstown Spring	8	91	7

County	Sample type	Location	Clostridia	Total Coli	Faecal Coli
	Drinking Water	Troyswood	31	0	0
	Drinking Water	Rades town Raw	17	934	61
	Drinking Water	Troyswood Raw	10	2152	462
Laois					
	Drinking Water	Errill	0	0	0
	Drinking Water	Misc	0	0	0
	Drinking Water	Emo	0	0	0
	Drinking Water	Ballybuggy	0	0	0
	Drinking Water	Ironmills	0	0	0
	Drinking Water	Rosenalis	0	0	0
	Drinking Water	Mountrath	0	0	0
	Drinking Water	Portarlington	1	0	0
	Drinking Water	Irishtown	0	0	0
	Drinking Water	Emo	0	0	0
	Drinking Water	Rathdowney	0	0	0
	Drinking Water	Donaghmore	4	0	0
	Drinking Water	Ballybuggy	1	0	0
	Drinking Water	Errill	10	0	0
	Drinking Water	Misc	0	0	0
	Drinking Water	Timahoe	3	0	0
	Drinking Water	Ballylynan	0	0	0
	Drinking Water	Rosenalis Shanbeg	3	0	0
	Drinking Water	Mountmellick	0	0	0
	Drinking Water	Portlaoise Mountrath Rd	0	0	0
	Drinking Water	Misc	2	0	0
	Drinking Water	Clonaslee	0	0	0
	Drinking Water	Portlaoise Dublin Road	0	0	0
	Drinking Water	Portlaoise Timahoe	0	0	0
	Drinking Water	Rosenalis Corbally	0	0	0
	Drinking Water	Portlaoise Dublin Rd	0	0	0
	Drinking Water	Portlaoise Meelick	0	0	0
	Drinking Water	Stradbally	0	0	0
	Drinking Water	Timahoe	0	3	0
	Drinking Water	Graiguecullen	0	0	0
	Drinking Water	The Strand	0	0	0
	Drinking Water	Arles	2	0	0
	Drinking Water	SE Regional - Ballylyna	0	0	0
	Drinking Water	Mountmellick	0	0	0
	Drinking Water	SE Regional -Stradbally	0	0	0

County	Sample type	Location	Clostridia	Total Coli	Faecal Coli
	Drinking Water	Portlaoise Emo	0	0	0
	Drinking Water	The Swan	0	5	0
	Drinking Water	Ballinakill	0	0	0
	Drinking Water	Portarlington	0	0	0
	Drinking Water	Clonaslee	0	0	0
	Drinking Water	Rosenalis	0	0	0
	Drinking Water	Shanbeg	56	24	0
	Drinking Water	Mountmellick	0	0	0
	Drinking Water	SE Regional - Vicarstow	0	0	0
	Drinking Water	Durrow	0	0	0
Tipp North					
	Drinking Water	Thurles (Toberaloo)	0	1	0
	Drinking Water	Roscrea	0	0	0
	Drinking Water	Glenbeha	0	0	0
	Drinking Water	Glenbeha (Raw)	45	64	11
	Drinking Water	Templemore	0	0	0
	Drinking Water	Nenagh	0	0	0
	Drinking Water	Borrisokane	1	0	0
	Drinking Water	Cloughjordan	100	0	0
	Drinking Water	Glashahulla (Raw)	100	365	84
	Drinking Water	Newport	0	0	0
	Drinking Water	Kilcommon	0	0	0
	Drinking Water	Bouladuff	0	0	0
	Drinking Water	Roscrea	0	0	0
	Drinking Water	Templemore	0	11	4
	Drinking Water	Nenagh	0	0	0
	Drinking Water	Borrisokane	0	95	2
	Drinking Water	Borrisoleigh	0	0	0
	Drinking Water	Roscrea	0	0	0
	Drinking Water	Thurles (Water Tower)	0	0	0
	Drinking Water	Thurles (Water Tower)	82	0	0
	Drinking Water	Thurles	0	0	0
	Drinking Water	Borrisoleigh	0	0	0
	Drinking Water	Kilcommon	0	0	0
	Drinking Water	Newport	0	0	0
	Drinking Water	Cloughjordan	12	19	1
Tipp South					
	Drinking Water	Grangemockler	0	2	0
	Drinking Water	Clonmel	16	0	0

County	Sample type	Location	Clostridia	Total Coli	Faecal Coli
	Drinking Water	Carrick-on-Suir	0	0	0
	Drinking Water	Carrigbeg	0	0	0
	Drinking Water	Clonmel	0	0	0
	Drinking Water	Ahenny	0	0	0
	Drinking Water	Coalbrook	0	0	0
	Drinking Water	Faugheen	0	0	0
	Drinking Water	Killenaule	0	0	0
	Drinking Water	Fethard (cloran)	0	6	3
	Drinking Water	Galtee Regional	0	0	0
	Drinking Water	Fetheard (Gortnapisha)	0	1	0
	Drinking Water	Kilcash	0	0	0
	Drinking Water	Cahir	0	0	0
	Drinking Water	Ballinvar	4	0	0
	Drinking Water	Commons	0	0	0
	Drinking Water	Carrick-on-Suir	0	0	0
	Drinking Water	Carrigbeg	0	0	0
	Drinking Water	Clonmel(Davis Rd)	80	201	165
	Drinking Water	Clonmel (Irishtown)	14	1	0
	Drinking Water	Cahir	0	0	0
	Drinking Water	Clogheen	0	0	0
	Drinking Water	Burncourt	0	2	0
	Drinking Water	Mullinahone	0	0	0
	Drinking Water	Ahenny	0	0	0
	Drinking Water	Cahir Res	0	0	0
	Drinking Water	Clogheen	1	0	0
	Drinking Water	Burncourt	2	0	0
	Drinking Water	Bansha	0	0	0
	Drinking Water	Tipp UDC	0	0	0
	Drinking Water	Ballincurry	0	0	0
	Drinking Water	Ballinvar	0	0	0
	Drinking Water	Emly/Lattin	0	0	0
	Drinking Water	Glengar	0	0	0
	Drinking Water	Cappawhite	0	0	0
	Drinking Water	Dundrum	0	0	0
	Drinking Water	Boherlahan	0	0	0
	Drinking Water	Inchirourke	0	3	0
	Drinking Water	Hollyford	0	0	0
	Drinking Water	Tullahea	0	0	0
Waterford City					

County	Sample type	Location	Clostridia	Total Coli	Faecal Coli
	Drinking Water	Military Road	0	0	0
	Drinking Water	Military Road	0	0	0
	Drinking Water	Tycor	0	0	0
	Drinking Water	Cork Rd	0	0	0
	Drinking Water	Cork Road/Tramore Rd	0	0	0
	Drinking Water	Ardkeen	0	0	0
	Drinking Water	Peoples Park	0	0	0
	Drinking Water	Ferrybank	0	0	0
	Drinking Water	Tycor	0	0	0
	Drinking Water	Dunmore East	0	0	0
	Drinking Water	Peoples Park	0	0	0
	Drinking Water	Ferrybank	0	0	0
	Drinking Water	Tramore Rd	0	0	0
	Drinking Water	Cork Road	0	0	0

Ground Water1

County	Sample type	Location	Clostridia	Total Coli	Faecal Coli
Carlow					
	Ground Water	01400	0	0	0
	Ground Water	00430	0	0	0
	Ground Water	00550	0	0	0
	Ground Water	00230	0	201	1
	Ground Water	00100	0	0	0
	Ground Water	00600	0	0	0
	Ground Water	00900	0	0	0
	Ground Water	00800	1	1	0
	Ground Water	01300	0	0	0
	Ground Water	01500	0	0	0
	Ground Water	00700	0	0	0
Kilkenny					
	Ground Water	01500	100	113	9
	Ground Water	Lacken	0	0	0
	Ground Water	Kennyswell	3	0	0
	Ground Water	00400	6	0	0
	Ground Water	02000	1	1203	197
	Ground Water	00500	100	1	0
	Ground Water	01900	0	23	0
	Ground Water	00800	0	54	1
	Ground Water	01400	1	3	0
	Ground Water	01300	30	44	0
	Ground Water	01000	100	0	0
	Ground Water	00700	3	0	0
	Ground Water	Misc	100	1120	31
	Ground Water	00300	0	4	0
	Ground Water	00100	34	222	3
	Ground Water	00200	0	0	0
Laois					
	Ground Water	13	56	0	0
	Ground Water	Farmoyle	0	0	0
	Ground Water	Abbeyleix (2)	0	6	0
	Ground Water	Abbeyleix	0	3	2
	Ground Water	37	0	0	0
	Ground Water	14	0	0	0

County	Sample type	Location	Clostridia	Total Coli	Faecal Coli
	Ground Water	40	0	0	0
	Ground Water	28	0	0	0
	Ground Water	19	4	3	0
	Ground Water	5	100	200	200
	Ground Water	23	100	200	19
	Ground Water	39	0	0	0
	Ground Water	1	0	0	0
	Ground Water	3	0	0	0
	Ground Water	Donaghmore	0	18	0
	Ground Water	Durrow	78	200	95
	Ground Water	Edenderry	0	0	0
	Ground Water	22	0	0	0
Offally					
	Ground Water	Clonaslee	0	0	0
	Ground Water	Rhodia	0	200	36
	Ground Water	Rahan	0	48	0
	Ground Water	Walsh Island	0	0	0
	Ground Water	Ferbane	0	0	0
	Ground Water	Banagher	0	0	0
	Ground Water	Geashill	0	200	1
	Ground Water	Cloreen	0	19	0
	Ground Water	Knocks	0	2	0
	Ground Water	Dunkerrin	0	38	1
Offaly					
	Ground Water	27	0	36	4
	Ground Water	23	80	0	0
	Ground Water	28	0	0	0
	Ground Water	13	1	2	1
	Ground Water	21	0	11	1
	Ground Water	19	0	0	0
	Ground Water	11	0	1	0
	Ground Water	3	4	145	19
	Ground Water	10	2	1	0
	Ground Water	4	0	2	0
	Ground Water	29	0	0	0
Tipp South					
	Ground Water	02200	0	43	1
	Ground Water	00810	0	2	0
	Ground Water	02000	100	201	36

County	Sample type	Location	Clostridia	Total Coli	Faecal Coli
	Ground Water	00600	0	11	0
	Ground Water	01900	0	0	0
	Ground Water	00900	100	201	38
	Ground Water	00100	100	101	3
	Ground Water	00500	2	8	3
	Ground Water	01400	0	15	0
	Ground Water	00700	1	3	0
	Ground Water	00400	0	0	0
	Ground Water	01600	0	0	0
	Ground Water	00800	61	70	6
	Ground Water	00814	0	0	0
	Ground Water	00300	0	0	0
	Ground Water	01010	5	50	6
	Ground Water	00815	0	0	0
	Ground Water	01300	5	50	1
	Ground Water	01200	0	0	0
	Ground Water	01100	0	3	2
	Ground Water	00200	10	78	2
	Ground Water	01800	15	0	0
	Ground Water	01700	0	0	0
	Ground Water	01000	11	10	5
	Ground Water	00812	24	9	0
Waterford					
	Ground Water	01100	0	0	0
	Ground Water	00500	0	10	0
	Ground Water	01900	67	83	31
	Ground Water	00800	1	0	0
	Ground Water	01600	3	12	0
	Ground Water	01800	0	1	0
	Ground Water	02000	0	0	0
	Ground Water	01300	0	0	0
	Ground Water	01500	16	9	1
	Ground Water	00900	2	0	0
	Ground Water	01200	0	0	0
	Ground Water	00200	0	0	0
	Ground Water	00100	0	0	0
	Ground Water	00400	0	1	0
	Ground Water	00700	0	6	0
	Ground Water	00600	0	2	0

County	Sample type	Location	Clostridia	Total Coli	Faecal Coli
	Ground Water	01000	0	0	0
	Ground Water	01700	0	0	0
	Ground Water	01400	0	0	0
Wexford					
	Ground Water	01900	0	2	0
	Ground Water	00900	0	10	0
	Ground Water	01000	11	1	0
	Ground Water	00800	5	0	0
	Ground Water	01200	0	0	0
	Ground Water	00500	9	12	0
	Ground Water	00200	2	1	0
	Ground Water	00300	0	0	0
	Ground Water	00100	9	43	12
	Ground Water	00400	0	0	0
	Ground Water	01700	6	0	0
	Ground Water	00600	0	0	0
	Ground Water	02200	1	15	0
	Ground Water	01400	0	0	0
	Ground Water	01600	4	3	0
	Ground Water	01500	0	0	0
	Ground Water	02000	0	3	0
	Ground Water	01800	0	0	0
	Ground Water	Borrisokane	5	15	2
	Ground Water	00700	0	0	0

Surface Waters

County	Location Cod	Clostridia	Total Coli	Faecal Coli	Water Supply
	16/K/03/01	0	770	2	
Carlow					
	14/A/03/02	0	582	4	New Ross
Laois					
	14/O/01/005	100	1986	344	Mountmellick
Tipp Nr					
	25/K/04/005	2500	0	0	Silvermines
Tipp Sr					
	16/C/03/005	100	12	1	Carrick-on-suir
	16/P/03/01	100	1633	234	Clonmel
	16/G/05/05	100	1733	866	Ardfinnan
	16/G/05/004	100	365	236	Ardfinnan
	16/D/03/14	100	0	0	Old Clogheen
	16/C/10/01	14	0	0	Galtee regional
	16/M/06/0050	0	0	0	Tipp Town
	16/R/05/01	2	727	9	Cahir
	16/P/03/02	300	4838	4838	Clonmel
	16/D/03/14	6	179	0	Old Clogheen
	16/G/05/0040	2	488	0	Ardfinnan
	16/G/05/005	2	548	1	Ardfinnan
	16/M/06/0200	4	0	0	Galtee Regional
	16/G/02/05	0	4838	4838	Clonmel
Waterford					
	18/K/03/01	13	1268	395	Tallow
	18/M/04/01	0	72	15	Ring/Helvic
	17/D/03/01	0	224	63	Deelish
	17/B/03/01	0	3447	494	Bunmahon
	17/B/02/01	0	866	34	Tramore
	18/G/06/02	0	110	83	Lismore
	17/B/04/01	3	145	1	Dunmore East
	18/G/06/01	2	433	97	Lismore
	17/C/02/01	82	980	3	Tramore
Wexford					
	14/A/03/02	100	804	172	New Ross
	12/B/02/0012	80	201	101	Ballywilliam

County	Location Cod	Clostridia	Total Coli	Faecal Coli	Water Supply
	12/B/02/0012	0	1195	6	Ballywilliam
	13/C/01/012	20	3973	108	Proposed
	12/D/01/07	10	1226	37	Bunclody
	12/B/02/034	14	3106	124	Proposed
	13/C/01/0120	4	0	0	Proposed
	12/B/02/0010	16	332	96	Rathnure
	12/D/07/01	59	0	0	Bunclody
	13/M/01/02	95	0	0	Taghmon
	12/B/02/0010	100	0	0	Rathnure
	13/C/01/0120	50	2010	740	Proposed
	12/B/02/0010	0	1961	13	Rathnure
	12/B/02/0012	100	201	53	Ballywilliam
	12/D/07/01	50	0	0	Bunclody
	13/O/01/024	100	1986	129	Wexford S Reg
	14/A/03/02	100	0	0	New Ross

Appendix 4: Council Directive 98/83/EC

COUNCIL DIRECTIVE 98/83/EC

of 3 November 1998

on the quality of water intended for human consumption

THE COUNCIL OF THE EUROPEAN UNION,

Having regard to the Treaty establishing the European Community and, in particular, Article 130s(1) thereof,

Having regard to the proposal from the Commission [1],

Having regard to the opinion of the Economic and Social Committee [2],

Having regard to the opinion of the Committee of the Regions [3],

Acting in accordance with the procedure laid down in Article 189c [4],

(1) Whereas it is necessary to adapt Council Directive 80/778/EEC of 15 July 1980 relating to the quality of water intended for human consumption [5] to scientific and technological progress; whereas experience gained from implementing that Directive shows that it is necessary to create an appropriately flexible and transparent legal framework for Member States to address failures to meet the standards; whereas, furthermore, that Directive should be re-examined in the light of the Treaty on European Union and in particular the principle of subsidiarity;

(2) Whereas in keeping with Article 3b of the Treaty, which provides that no Community action should go beyond what is necessary to achieve the objectives of the Treaty, it is necessary to revise Directive 80/778/EEC so as to focus on compliance with essential quality and health parameters, leaving Member States free to add other parameters if they see fit;

(3) Whereas, in accordance with the principle of subsidiarity, Community action must support and supplement action by the competent authorities in the Member States;

(4) Whereas, in accordance with the principle of subsidiarity, the natural and socio-economic differences between the regions of the Union require that most decisions on monitoring, analysis, and the measures to be taken to redress failures be taken at a local, regional or national level insofar as those differences do not detract from the establishment of the framework of laws, regulations and administrative provisions laid down in this Directive;

(5) Whereas Community standards for essential and preventive health-related quality parameters in water intended for human consumption are necessary if minimum environmental-quality goals to be achieved in connection with other Community measures are to be defined so that the sustainable use of water intended for human consumption may be safeguarded and promoted;

(6) Whereas, in view of the importance of the quality of water intended for human consumption for human health, it is necessary to lay down at Community level the essential quality standards with which water intended for that purpose must comply;

(7) Whereas it is necessary to include water used in the food industry unless it can be established that the use of such water does not affect the wholesomeness of the finished product;

(8) Whereas to enable water-supply undertakings to meet the quality standards for drinking water, appropriate water-protection measures should be applied to ensure that surface and groundwater is kept clean; whereas the same goal can be achieved by appropriate water-treatment measures to be applied before supply;

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(1) OJ C 131, 30.5.1995, p. 5 and OJ C 213, 15.7.1997, p. 8.

(2) OJ C 82, 19.3.1996, p. 64.

(3) OJ C 100, 2.4.1996, p. 134.

(4) Opinion of the European Parliament of 12 December 1996 (OJ C 20, 20.1.1997, p. 133), Council common position of 19 December 1997 (OJ C 91, 26.3.1998, p. 1) and Decision of the European Parliament of 13 May 1998 (OJ C 167, 1.6.1998, p. 92).

(5) OJ L 229, 30.8.1980, p. 11. Directive as last amended by the 1994 Act of Accession.

(9) Whereas the coherence of European water policy presupposes that a suitable water framework Directive will be adopted in due course;

(10) Whereas it is necessary to exclude from the scope of this Directive natural mineral waters and waters which are medicinal products, since special rules for those types of water have been established;

(11) Whereas measures are required for all parameters directly relevant to health and for other parameters if a deterioration in quality has occurred; whereas, furthermore, such measures should be carefully coordinated with the implementation of Council Directive 91/414/EEC of 15 July 1991 concerning the placing of plant protection products on the market (1) and Directive 98/8/EC of the European Parliament and of the Council of 16 February 1998 concerning the placing of biocidal products on the market (2);

(12) Whereas it is necessary to set individual parametric values for substances which are important throughout the Community at a level strict enough to ensure that this Directive's purpose can be achieved;

(13) Whereas the parametric values are based on the scientific knowledge available and the precautionary principle has also been taken into account; whereas those values have been selected to ensure that water intended for human consumption can be consumed safely on a life-long basis, and thus represent a high level of health protection;

(14) Whereas a balance should be struck to prevent both microbiological and chemical risks; whereas, to that end, and in the light of a future review of the parametric values, the establishment of parametric values applicable to water intended for human consumption should be based on public-health considerations and on a method of assessing risk;

(15) Whereas there is at present insufficient evidence on which to base parametric values for endocrine-disrupting chemicals at Community level, yet there is increasing concern regarding the potential impact on humans and wildlife of the effects of substances harmful to health;

(16) Whereas in particular the standards in Annex I are generally based on the World Health Organisation's 'Guidelines for drinking water quality', and the opinion of the Commission's Scientific Advisory Committee to examine the toxicity and ecotoxicity of chemical compounds;

(17) Whereas Member States must set values for other additional parameters not included in Annex I where that is necessary to protect human health within their territories;

(18) Whereas Member States may set values for other additional parameters not included in Annex I where that is deemed necessary for the purpose of ensuring the quality of the production, distribution and inspection of water intended for human consumption;

(19) Whereas, when Member States deem it necessary to adopt standards more stringent than those set out in Annex I, Parts A and B, or standards for additional parameters not included in Annex I but necessary to protect human health, they must notify the Commission of those standards;

(20) Whereas Member States are bound, when introducing or maintaining more stringent protection measures, to respect the principles and rules of the Treaty, as they are interpreted by the Court of Justice;

(21) Whereas the parametric values are to be complied with at the point where water intended for human consumption is made available to the appropriate user;

(22) Whereas the quality of water intended for human consumption can be influenced by the domestic distribution system; whereas, furthermore, it is recognised that neither the domestic distribution system nor its maintenance may be the responsibility of the Member States;

(23) Whereas each Member State should establish monitoring programmes to check that water intended for human consumption meets the requirements of this Directive; whereas such monitoring programmes should be appropriate to local needs and should meet the minimum monitoring requirements laid down in this Directive;

(24) Whereas the methods used to analyse the quality of water intended for human consumption should be such as to ensure that the results obtained are reliable and comparable;

(1) OJ L 230, 19.8.1991, p. 1. Directive as last amended by Commission Directive 96/68/EC (OJ L 277, 30.10.1996, p. 25).
(2) OJ L 123, 24.4.1998, p. 1.

(25) Whereas, in the event of non-compliance with the standards imposed by this Directive the Member State concerned should investigate the cause and ensure that the necessary remedial action is taken as soon as possible to restore the quality of the water;

(26) Whereas it is important to prevent contaminated water causing a potential danger to human health; whereas the supply of such water should be prohibited or its use restricted;

(27) Whereas, in the event of non-compliance with a parameter that has an indicator function, the Member State concerned must consider whether that non-compliance poses any risk to human health; whereas it should take remedial action to restore the quality of the water where that is necessary to protect human health;

(28) Whereas, should such remedial action be necessary to restore the quality of water intended for human consumption, in accordance with Article 130r(2) of the Treaty, priority should be given to action which rectifies the problem at source;

(29) Whereas Member States should be authorised, under certain conditions, to grant derogations from this Directive; whereas, furthermore, it is necessary to establish a proper framework for such derogations, provided that they must not constitute a potential danger to human health and provided that the supply of water intended for human consumption in the area concerned cannot otherwise be maintained by any other reasonable means;

(30) Whereas, since the preparation or distribution of water intended for human consumption may involve the use of certain substances or materials, rules are required to govern the use thereof in order to avoid possible harmful effects on human health;

(31) Whereas scientific and technical progress may necessitate rapid adaptation of the technical requirements laid down in Annexes II and III; whereas, furthermore, in order to facilitate application of the measures required for that purpose, provision should be made for a procedure under which the Commission can adopt such adaptations with the assistance of a committee composed of representatives of the Member States;

(32) Whereas consumers should be adequately and appropriately informed of the quality of water intended for human consumption, of any derogations granted by the Member States and of any remedial action taken by the competent authorities; whereas, furthermore, consideration should be given both to the technical and statistical needs of the Commission, and to the rights of the individual to obtain adequate information concerning the quality of water intended for human consumption;

(33) Whereas, in exceptional circumstances and for geographically defined areas, it may be necessary to allow Member States a more extensive timescale for compliance with certain provisions of this Directive;

(34) Whereas this Directive should not affect the obligations of the Member States as to the time limit for transposition into national law, or as to application, as shown in Annex IV,

HAS ADOPTED THIS DIRECTIVE:

Article 1

Objective

1. This Directive concerns the quality of water intended for human consumption.

2. The objective of this Directive shall be to protect human health from the adverse effects of any contamination of water intended for human consumption by ensuring that it is wholesome and clean.

Article 2

Definitions

For the purposes of this Directive:

1. 'water intended for human consumption' shall mean:

   (a) all water either in its original state or after treatment, intended for drinking, cooking, food preparation or other domestic purposes, regardless of its origin and whether it is supplied from a distribution network, from a tanker, or in bottles or containers;

   (b) all water used in any food-production undertaking for the manufacture, processing, preservation or marketing of products or substances intended for human consumption unless the competent national authorities are satisfied that the quality of the water cannot affect the wholesomeness of the foodstuff in its finished form;

2. 'domestic distribution system' shall mean the pipework, fittings and appliances which are installed between the taps that are normally used for human consumption and the distribution network but only if they are not the responsibility of the water supplier, in its capacity as a water supplier, according to the relevant national law.

Article 3

Exemptions

1. This Directive shall not apply to:

(a) natural mineral waters recognised as such by the competent national authorities, in accordance with Council Directive 80/777/EEC of 15 July 1980 on the approximation of the laws of the Member States relating to the exploitation and marketing of natural mineral waters [1];

(b) waters which are medicinal products within the meaning of Council Directive 65/65/EEC of 26 January 1965 on the approximation of provisions laid down by law, regulation or administrative action relating to medicinal products [2].

2. Member States may exempt from the provisions of this Directive:

(a) water intended exclusively for those purposes for which the competent authorities are satisfied that the quality of the water has no influence, either directly or indirectly, on the health of the consumers concerned;

(b) water intended for human consumption from an individual supply providing less than 10 m^3 a day as an average or serving fewer than 50 persons, unless the water is supplied as part of a commercial or public activity.

3. Member States that have recourse to the exemptions provided for in paragraph 2(b) shall ensure that the population concerned is informed thereof and of any action that can be taken to protect human health from the adverse effects resulting from any contamination of water intended for human consumption. In addition, when a potential danger to human health arising out of the quality of such water is apparent, the population concerned shall promptly be given appropriate advice.

Article 4

General obligations

1. Without prejudice to their obligations under other Community provisions, Member States shall take the measures necessary to ensure that water intended for human consumption is wholesome and clean. For the purposes of the minimum requirements of this Directive, water intended for human consumption shall be wholesome and clean if it:

(a) is free from any micro-organisms and parasites and from any substances which, in numbers or concentrations, constitute a potential danger to human health, and

(b) meets the minimum requirements set out in Annex I, Parts A and B;

and if, in accordance with the relevant provisions of Articles 5 to 8 and 10 and in accordance with the Treaty, Member States take all other measures necessary to ensure that water intended for human consumption complies with the requirements of this Directive.

2. Member States shall ensure that the measures taken to implement this Directive in no circumstances have the effect of allowing, directly or indirectly, either any deterioration of the present quality of water intended for human consumption so far as that is relevant for the protection of human health or any increase in the pollution of waters used for the production of drinking water.

Article 5

Quality standards

1. Member States shall set values applicable to water intended for human consumption for the parameters set out in Annex I.

2. The values set in accordance with paragraph 1 shall not be less stringent than those set out in Annex I. As regards the parameters set out in Annex I, Part C, the values need be fixed only for monitoring purposes and for the fulfilment of the obligations imposed in Article 8.

3. A Member State shall set values for additiona parameters not included in Annex I where the protectio

(1) OJ L 229, 30.8.1980, p. 1. Directive as last amended by Directive 96/70/EC (OJ L 299, 23.11.1996, p. 26).
(2) OJ 22 9.2.1965, p. 369. Directive as last amended by Directive 93/39/EEC (OJ L 214, 24.8.1993, p. 22).

of human health within its national territory or part of it so requires. The values set should, as a minimum, satisfy the requirements of Article 4(1)(a).

Article 6

Point of compliance

1. The parametric values set in accordance with Article 5 shall be complied with:

(a) in the case of water supplied from a distribution network, at the point, within premises or an establishment, at which it emerges from the taps that are normally used for human consumption;

(b) in the case of water supplied from a tanker, at the point at which it emerges from the tanker;

(c) in the case of water put into bottles or containers intended for sale, at the point at which the water is put into the bottles or containers;

(d) in the case of water used in a food-production undertaking, at the point where the water is used in the undertaking.

2. In the case of water covered by paragraph 1(a), Member States shall be deemed to have fulfilled their obligations under this Article and under Articles 4 and 8(2) where it can be established that non-compliance with the parametric values set in accordance with Article 5 is due to the domestic distribution system or the maintenance thereof except in premises and establishments where water is supplied to the public, such as schools, hospitals and restaurants.

3. Where paragraph 2 applies and there is a risk that water covered by paragraph 1(a) would not comply with the parametric values established in accordance with Article 5, Member States shall nevertheless ensure that:

(a) appropriate measures are taken to reduce or eliminate the risk of non-compliance with the parametric values, such as advising property owners of any possible remedial action they could take, and/or

other measures, such as appropriate treatment techniques, are taken to change the nature or properties of the water before it is supplied so as to reduce or eliminate the risk of the water not complying with the parametric values after supply;

and

(b) the consumers concerned are duly informed and advised of any possible additional remedial action that they should take.

Article 7

Monitoring

1. Member States shall take all measures necessary to ensure that regular monitoring of the quality of water intended for human consumption is carried out, in order to check that the water available to consumers meets the requirements of this Directive and in particular the parametric values set in accordance with Article 5. Samples should be taken so that they are representative of the quality of the water consumed throughout the year. In addition, Member States shall take all measures necessary to ensure that, where disinfection forms part of the preparation or distribution of water intended for human consumption, the efficiency of the disinfection treatment applied is verified, and that any contamination from disinfection by-products is kept as low as possible without compromising the disinfection.

2. To meet the obligations imposed in paragraph 1, appropriate monitoring programmes shall be established by the competent authorities for all water intended for human consumption. Those monitoring programmes shall meet the minimum requirements set out in Annex II.

3. The sampling points shall be determined by the competent authorities and shall meet the relevant requirements set out in Annex II.

4. Community guidelines for the monitoring prescribed in this Article may be drawn up in accordance with the procedure laid down in Article 12.

5 (a) Member States shall comply with the specifications for the analyses of parameters set out in Annex III.

(b) Methods other than those specified in Annex III, Part 1, may be used, providing it can be demonstrated that the results obtained are at least as reliable as those produced by the methods specified. Member States which have recourse to alternative methods shall provide the Commission with all relevant information concerning such methods and their equivalence.

(c) For those parameters listed in Annex III, Parts 2 and 3, any method of analysis may be used provided that it meets the requirements set out therein.

6. Member States shall ensure that additional monitoring is carried out on a case-by-case basis of substances and micro-organisms for which no parametric value has been set in accordance with Article 5, if there is reason to suspect that they may be present in amounts or

numbers which constitute a potential danger to human health.

Article 8

Remedial action and restrictions in use

1. Member States shall ensure that any failure to meet the parametric values set in accordance with Article 5 is immediately investigated in order to identify the cause.

2. If, despite the measures taken to meet the obligations imposed in Article 4(1), water intended for human consumption does not meet the parametric values set in accordance with Article 5, and subject to Article 6(2), the Member State concerned shall ensure that the necessary remedial action is taken as soon as possible to restore its quality and shall give priority to their enforcement action, having regard *inter alia* to the extent to which the relevant parametric value has been exceeded and to the potential danger to human health.

3. Whether or not any failure to meet the parametric values has occurred, Member States shall ensure that any supply of water intended for human consumption which constitutes a potential danger to human health is prohibited or its use restricted or such other action is taken as is necessary to protect human health. In such cases consumers shall be informed promptly thereof and given the necessary advice.

4. The competent authorities or other relevant bodies shall decide what action under paragraph 3 should be taken, bearing in mind the risks to human health which would be caused by an interruption of the supply or a restriction in the use of water intended for human consumption.

5. Member States may establish guidelines to assist the competent authorities to fulfil their obligations under paragraph 4.

6. In the event of non-compliance with the parametric values or with the specifications set out in Annex I, Part C, Member States shall consider whether that non-compliance poses any risk to human health. They shall take remedial action to restore the quality of the water where that is necessary to protect human health.

7. Member States shall ensure that, where remedial action is taken, consumers are notified except where the competent authorities consider the non-compliance with the parametric value to be trivial.

Article 9

Derogations

1. Member States may provide for derogations from the parametric values set out in Annex I, Part B, or set in accordance with Article 5(3), up to a maximum value to be determined by them, provided no derogation constitutes a potential danger to human health and provided that the supply of water intended for human consumption in the area concerned cannot otherwise be maintained by any other reasonable means. Derogations shall be limited to as short a time as possible and shall not exceed three years, towards the end of which a review shall be conducted to determine whether sufficient progress has been made. Where a Member State intends to grant a second derogation, it shall communicate the review, along with the grounds for its decision on the second derogation, to the Commission. No such second derogation shall exceed three years.

2. In exceptional circumstances, a Member State may ask the Commission for a third derogation for a period not exceeding three years. The Commission shall take a decision on any such request within three months.

3. Any derogation granted in accordance with paragraphs 1 or 2 shall specify the following:

(a) the grounds for the derogation;

(b) the parameter concerned, previous relevant monitoring results, and the maximum permissible value under the derogation;

(c) the geographical area, the quantity of water supplied each day, the population concerned and whether or not any relevant food-production undertaking would be affected;

(d) an appropriate monitoring scheme, with an increased monitoring frequency where necessary;

(e) a summary of the plan for the necessary remedial action, including a timetable for the work and an estimate of the cost and provisions for reviewing;

(f) the required duration of the derogation.

4. If the competent authorities consider the non-compliance with the parametric value to be trivial, and if action taken in accordance with Article 8(2) is sufficient to remedy the problem within 30 days, the requirements of paragraph 3 need not be applied.

In that event, only the maximum permissible value for the parameter concerned and the time allowed to remedy the problem shall be set by the competent authorities or other relevant bodies.

5. Recourse may no longer be had to paragraph 4 if failure to comply with any one parametric value for a given water supply has occurred on more than 30 days on aggregate during the previous 12 months.

6. Any Member State which has recourse to the derogations provided for in this Article shall ensure that the population affected by any such derogation is promptly informed in an appropriate manner of the derogation and of the conditions governing it. In addition the Member State shall, where necessary, ensure that advice is given to particular population groups for which the derogation could present a special risk.

These obligations shall not apply in the circumstances described in paragraph 4 unless the competent authorities decide otherwise.

7. With the exception of derogations granted in accordance with paragraph 4 a Member State shall inform the Commission within two months of any derogation concerning an individual supply of water exceeding 1 000 m^3 a day as an average or serving more than 5 000 persons, including the information specified in paragraph 3.

8. This Article shall not apply to water intended for human consumption offered for sale in bottles or containers.

Article 10

Quality assurance of treatment, equipment and materials

Member States shall take all measures necessary to ensure that no substances or materials for new installations used in the preparation or distribution of water intended for human consumption or impurities associated with such substances or materials for new installations remain in water intended for human consumption in concentrations higher than is necessary for the purpose of their use and do not, either directly or indirectly, reduce the protection of human health provided for in this Directive; the interpretative document and technical specifications pursuant to Article 3 and Article 4 (1) of Council Directive 89/106/EEC of 21 December 1988 on the approximation of laws, regulations and administrative provisions of the Member States relating to construction products [1] shall respect the requirements of this Directive.

Article 11

Review of Annexes

1. At least every five years, the Commission shall review Annex I in the light of scientific and technical progress and shall make proposals for amendments, where necessary, under the procedure laid down in Article 189c of the Treaty.

2. At least every five years, the Commission shall adapt Annexes II and III to scientific and technical progress. Such changes as are necessary shall be adopted in accordance with the procedure laid down in Article 12.

Article 12

Committee procedure

1. The Commission shall be assisted by a committee composed of representatives of the Member States and chaired by a Commission representative.

2. The Commission representative shall submit to the committee a draft of the measures to be taken. The committee shall deliver its opinion on the draft within a time limit which the chairman may lay down according to the urgency of the matter. The opinion shall be delivered by the majority laid down in Article 148(2) of the Treaty in the case of decisions which the Council is required to adopt on a proposal from the Commission. The votes of the representatives of the Member States within the committee shall be weighted in the manner set out in that Article. The chairman shall not vote.

3. The Commission shall adopt measures which shall apply immediately. However, if those measures are not in accordance with the committee's opinion, the Commission shall communicate them to the Council forthwith. In that event:

(a) the Commission shall defer application of the measures which it has adopted for a period of three months from the date of communication;

(b) the Council, acting by a qualified majority, may take a different decision within the time limit referred to in point (a).

Article 13

Information and reporting

1. Member States shall take the measures necessary to ensure that adequate and up-to-date information on the

[1] OJ L 40, 11.2.1989, p. 12. Directive as last amended by Directive 93/68/EEC (OJ L 220, 30.8.1993, p. 1).

quality of water intended for human consumption is available to consumers.

2. Without prejudice to Council Directive 90/313/EEC of 7 June 1990 on the freedom of access to information on the environment [1], each Member State shall publish a report every three years on the quality of water intended for human consumption with the objective of informing consumers. The first report shall cover the years 2002, 2003 and 2004. Each report shall include, as a minimum, all individual supplies of water exceeding 1 000 m^3 a day as an average or serving more than 5 000 persons and it shall cover three calendar years and be published within one calendar year of the end of the reporting period.

3. Member States shall send their reports to the Commission within two months of their publication.

4. The formats and the minimum information for the reports provided for in paragraph 2 shall be determined having special regard to the measures referred to in Article 3(2), Article 5(2) and (3), Article 7(2), Article 8, Article 9(6) and (7) and 15(1), and shall if necessary be amended in accordance with the procedure laid down in Article 12.

5. The Commission shall examine the Member States' reports and, every three years, publish a synthesis report on the quality of water intended for human consumption in the Community. That report shall be published within nine months of the receipt of the Member States' reports.

6. Together with the first report on this Directive as mentioned in paragraph 2, Member States shall also produce a report to be forwarded to the Commission on the measures they have taken or plan to take to fultil their obligations pursuant to Article 6(3) and Annex I, Part B, note 10. The Commission shall submit, as appropriate, a proposal on the format of this report in accordance with the procedure laid down in Article 12.

Article 14

Timescale for compliance

Member States shall take the measures necessary to ensure that the quality of water intended for human consumption complies with this Directive within five years of its entry into force, without prejudice to Notes 2, 4 and 10 in Annex I, Part B.

(1) OJ L 158, 23.6.1990, p. 56.

Article 15

Exceptional circumstances

1. A Member State may, in exceptional circumstances and for geographically defined areas, submit a special request to the Commission for a period longer than that laid down in Article 14. The additional period shall not exceed three years, towards the end of which a review shall be carried out and forwarded to the Commission which may, on the basis of that review, permit a second additional period of up to three years. This provision shall not apply to water intended for human consumption offered for sale in bottles or containers.

2. Any such request, grounds for which shall be given, shall set out the difficulties experienced and include, as a minimum, all the information specified in Article 9(3).

3. The Commission shall examine that request in accordance with the procedure laid down in Article 12.

4. Any Member State which has recourse to this Article shall ensure that the population affected by its request is promptly informed in an appropriate manner of the outcome of that request. In addition, the Member State shall, where necessary, ensure that advice is given to particular population groups for which the request could present a special risk.

Article 16

Repeal

1. Directive 80/778/EEC is hereby repealed with effect from five years after the entry into force of this Directive. Subject to paragraph 2, this repeal shall be without prejudice to Member States' obligations regarding deadlines for transposition into national law and for application as shown in Annex IV.

Any reference to the Directive repealed shall be construed as a reference to this Directive and shall be read in accordance with the correlation table set out in Annex V.

2. As soon as a Member State has brought into force the laws, regulations and administrative provisions necessary to comply with this Directive and has taken the measures provided for in Article 14, this Directive, not Directive 80/778/EEC, shall apply to the quality of water intended for human consumption in that Member State.

Article 17

Transposition into national law

1. Member States shall bring into force the laws, regulations and administrative provisions necessary to comply with this Directive within two years of its entry into force. They shall forthwith inform the Commission thereof.

When the Member States adopt those measures, these shall contain references to this Directive or shall be accompanied by such references on the occasion of their official publication. The methods of making such references shall be laid down by the Member States.

2. The Member States shall communicate to the Commission the texts of the provisions of national law which they adopt in the field covered by this Directive.

Article 18

Entry into force

This Directive shall enter into force on the 20th day following its publication in the *Official Journal of the European Communities*.

Article 19

Addressees

This Directive is addressed to the Member States.

Done at Brussels, 3 November 1998.

For the Council

The President

B. PRAMMER

ANNEX I

PARAMETERS AND PARAMETRIC VALUES

PART A

Microbiological parameters

Parameter	Parametric value (number/100 ml)
Escherichia coli (E. coli)	0
Enterococci	0

The following applies to water offered for sale in bottles or containers:

Parameter	Parametric value
Escherichia coli (E. coli)	0/250 ml
Enterococci	0/250 ml
Pseudomonas aeruginosa	0/250 ml
Colony count 22 °C	100/ml
Colony count 37 °C	20/ml

PART B

Chemical parameters

Parameter	Parametric value	Unit	Notes
Acrylamide	0,10	μg/l	Note 1
Antimony	5,0	μg/l	
Arsenic	10	μg/l	
Benzene	1,0	μg/l	
Benzo(a)pyrene	0,010	μg/l	
Boron	1,0	mg/l	
Bromate	10	μg/l	Note 2
Cadmium	5,0	μg/l	
Chromium	50	μg/l	
Copper	2,0	mg/l	Note 3
Cyanide	50	μg/l	
1,2-dichloroethane	3,0	μg/l	
Epichlorohydrin	0,10	μg/l	Note 1
Fluoride	1,5	mg/l	
Lead	10	μg/l	Notes 3 and 4
Mercury	1,0	μg/l	
Nickel	20	μg/l	Note 3
Nitrate	50	mg/l	Note 5
Nitrite	0,50	mg/l	Note 5
Pesticides	0,10	μg/l	Notes 6 and 7
Pesticides — Total	0,50	μg/l	Notes 6 and 8
Polycyclic aromatic hydrocarbons	0,10	μg/l	Sum of concentrations of specified compounds; Note 9
Selenium	10	μg/l	
Tetrachloroethene and Trichloroethene	10	μg/l	Sum of concentrations of specified parameters
Trihalomethanes — Total	100	μg/l	Sum of concentrations of specified compounds; Note 10
Vinyl chloride	0,50	μg/l	Note 1

Note 1: The parametric value refers to the residual monomer concentration in the water as calculated according to specifications of the maximum release from the corresponding polymer in contact with the water.

Note 2: Where possible, without compromising disinfection, Member States should strive for a lower value.

For the water referred to in Article 6(1)(a), (b) and (d), the value must be met, at the latest, 10 calendar years after the entry into force of the Directive. The parametric value for bromate from five years after the entry into force of this Directive until 10 years after its entry into force is 25 μg/l.

Note 3: The value applies to a sample of water intended for human consumption obtained by an adequate sampling method ([1]) at the tap and taken so as to be representative of a weekly average value ingested by consumers. Where appropriate the sampling and monitoring methods must be applied in a harmonised fashion to be drawn up in accordance with Article 7(4). Member States must take account of the occurrence of peak levels that may cause adverse effects on human health.

Note 4: For water referred to in Article 6(1)(a), (b) and (d), the value must be met, at the latest, 15 calendar years after the entry into force of this Directive. The parametric value for lead from five years after the entry into force of this Directive until 15 years after its entry into force is 25 μg/l.

Member States must ensure that all appropriate measures are taken to reduce the concentration of lead in water intended for human consumption as much as possible during the period needed to achieve compliance with the parametric value.

When implementing the measures to achieve compliance with that value Member States must progressively give priority where lead concentrations in water intended for human consumption are highest.

Note 5: Member States must ensure that the condition that [nitrate]/50 + [nitrite]/3 ≤ 1, the square brackets signifying the concentrations in mg/l for nitrate (NO_3) and nitrite (NO_2), is complied with and that the value of 0,10 mg/l for nitrites is complied with ex water treatment works.

Note 6: 'Pesticides' means:

- organic insecticides,
- organic herbicides,
- organic fungicides,
- organic nematocides,
- organic acaricides,
- organic algicides,
- organic rodenticides
- organic slimicides,
- related products (*inter alia*, growth regulators)

and their relevant metabolites, degradation and reaction products.

Only those pesticides which are likely to be present in a given supply need be monitored.

Note 7: The parametric value applies to each individual pesticide. In the case of aldrin, dieldrin, heptachlor and heptachlor epoxide the parametric value is 0,030 μg/l.

Note 8: 'Pesticides — Total' means the sum of all individual pesticides detected and quantified in the monitoring procedure.

Note 9: The specified compounds are:

- benzo(b)fluoranthene,
- benzo(k)fluoranthene,
- benzo(ghi)perylene,
- indeno(1,2,3-cd)pyrene.

Note 10: Where possible, without compromising disinfection, Member States should strive for a lower value.

The specified compounds are: chloroform, bromoform, dibromochloromethane, bromodichloromethane.

For the water referred to in Article 6(1)(a), (b) and (d), the value must be met, at the latest, 10 calendar years after the entry into force of this Directive. The parametric value for total THMs from five years after the entry into force of this Directive until 10 years after its entry into force is 150 μg/l.

([1]) To be added following the outcome of the study currently being carried out.

Member States must ensure that all appropriate measures are taken to reduce the concentration of THMs in water intended for human consumption as much as possible during the period needed to achieve compliance with the parametric value.

When implementing the measures to achieve this value, Member States must progressively give priority to those areas where THM concentrations in water intended for human consumption are highest.

PART C

Indicator parameters

Parameter	Parametric value	Unit	Notes
Aluminium	200	µg/l	
Ammonium	0,50	mg/l	
Chloride	250	mg/l	Note 1
Clostridium perfringens (including spores)	0	number/100 ml	Note 2
Colour	Acceptable to consumers and no abnormal change		
Conductivity	2 500	$\mu S\ cm^{-1}$ at 20 °C	Note 1
Hydrogen ion concentration	≥ 6,5 and ≤ 9,5	pH units	Notes 1 and 3
Iron	200	µg/l	
Manganese	50	µg/l	
Odour	Acceptable to consumers and no abnormal change		
Oxidisability	5,0	mg/l O_2	Note 4
Sulphate	250	mg/l	Note 1
Sodium	200	mg/l	
Taste	Acceptable to consumers and no abnormal change		
Colony count 22°	No abnormal change		
Coliform bacteria	0	number/100 ml	Note 5
Total organic carbon (TOC)	No abnormal change		Note 6
Turbidity	Acceptable to consumers and no abnormal change		Note 7

RADIOACTIVITY

Parameter	Parametric value	Unit	Notes
Tritium	100	Bq/l	Notes 8 and 10
Total indicative dose	0,10	mSv/year	Notes 9 and 10

Note 1: The water should not be aggressive.

Note 2: This parameter need not be measured unless the water originates from or is influenced by surface water. In the event of non-compliance with this parametric value, the Member State concerned must investigate the supply to ensure that there is no potential danger to human health arising from the presence of pathogenic micro-organisms, e.g. cryptosporidium. Member States must include the results of all such investigations in the reports they must submit under Article 13(2).

Note 3: For still water put into bottles or containers, the minimum value may be reduced to 4,5 pH units.

For water put into bottles or containers which is naturally rich in or artificially enriched with carbon dioxide, the minimum value may be lower.

Note 4: This parameter need not be measured if the parameter TOC is analysed.

Note 5: For water put into bottles or containers the unit is number/250 ml.

Note 6: This parameter need not be measured for supplies of less than 10 000 m^3 a day.

Note 7: In the case of surface water treatment, Member States should strive for a parametric value not exceeding 1,0 NTU (nephelometric turbidity units) in the water ex treatment works.

Note 8: Monitoring frequencies to be set later in Annex II.

Note 9: Excluding tritium, potassium -40, radon and radon decay products; monitoring frequencies, monitoring methods and the most relevant locations for monitoring points to be set later in Annex II.

Note 10:

1. The proposals required by Note 8 on monitoring frequencies, and Note 9 on monitoring frequencies, monitoring methods and the most relevant locations for monitoring points in Annex II shall be adopted in accordance with the procedure laid down in Article 12. When elaborating these proposals the Commission shall take into account *inter alia* the relevant provisions under existing legislation or appropriate monitoring programmes including monitoring results as derived from them. The Commission shall submit these proposals at the latest within 18 months following the date referred to in Article 18 of the Directive.
2. A Member State is not required to monitor drinking water for tritium or radioactivity to establish total indicative dose where it is satisfied that, on the basis of other monitoring carried out, the levels of tritium of the calculated total indicative dose are well below the parametric value. In that case, it shall communicate the grounds for its decision to the Commission, including the results of this other monitoring carried out.

ANNEX II

MONITORING

TABLE A

Parameters to be analysed

1. *Check monitoring*

The purpose of check monitoring is regularly to provide information on the organoleptic and microbiological quality of the water supplied for human consumption as well as information on the effectiveness of drinking-water treatment (particularly of disinfection) where it is used, in order to determine whether or not water intended for human consumption complies with the relevant parametric values laid down in this Directive.

The following parameters must be subject to check monitoring. Member States may add other parameters to this list if they deem it appropriate.

Aluminium (Note 1)

Ammonium

Colour

Conductivity

Clostridium perfringens (including spores) (Note 2)

Escherichia coli (E. coli)

Hydrogen ion concentration

Iron (Note 1)

Nitrite (Note 3)

Odour

Pseudomonas aeruginosa (Note 4)

Taste

Colony count 22 °C and 37 °C (Note 4)

Coliform bacteria

Turbidity

Note 1: Necessary only when used as flocculant (*).

Note 2: Necessary only if the water originates from or is influenced by surface water (*).

Note 3: Necessary only when chloramination is used as a disinfectant (*).

Note 4: Necessary only in the case of water offered for sale in bottles or containers.

(*) In all other cases, the parameters are in the list for audit monitoring.

2. *Audit monitoring*

The purpose of audit monitoring is to provide the information necessary to determine whether or not all of the Directive's parametric values are being complied with. All parameters set in accordance with Article 5(2) and (3) must be subject to audit monitoring unless it can be established by the competent authorities, for a period of time to be determined by them, that a parameter is not likely to be present in a given supply in concentrations which could lead to the risk of a breach of the relevant parametric value. This paragraph does not apply to the parameters for radioactivity, which, subject to Notes 8, 9 and 10 in Annex I, Part C, will be monitored in accordance with monitoring requirements adopted under Article 12.

TABLE B1

Minimum frequency of sampling and analyses for water intended for human consumption supplied from a distribution network or from a tanker or used in a food-production undertaking

Member States must take samples at the points of compliance as defined in Article 6(1) to ensure that water intended for human consumption meets the requirements of the Directive. However, in the case of a distribution network, a Member State may take samples within the supply zone or at the treatment works for particular parameters if it can be demonstrated that there would be no adverse change to the measured value of the parameters concerned.

Volume of water distributed or produced each day within a supply zone (Notes 1 and 2) m^3		Check monitoring number of samples per year (Notes 3, 4 and 5)	Audit monitoring number of samples per year (Notes 3 and 5)
	≤ 100	(Note 6)	(Note 6)
> 100	≤ 1 000	4	1
> 1 000	≤ 10 000		1 + 1 for each 3 300 m^3/d and part thereof of the total volume
> 10 000	≤ 100 000	4 + 3 for each 1 000 m^3/d and part thereof of the total volume	3 + 1 for each 10 000 m^3/d and part thereof of the total volume
> 100 000			10 + 1 for each 25 000 m^3/d and part thereof of the total volume

Note 1: A supply zone is a geographically defined area within which water intended for human consumption comes from one or more sources and within which water quality may be considered as being approximately uniform.

Note 2: The volumes are calculated as averages taken over a calendar year. A Member State may use the number of inhabitants in a supply zone instead of the volume of water to determine the minimum frequency, assuming a water consumption of 200 l/day/capita.

Note 3: In the event of intermittent short-term supply the monitoring frequency of water distributed by tankers is to be decided by the Member State concerned.

Note 4: For the different parameters in Annex I, a Member State may reduce the number of samples specified in the table if:

(a) the values of the results obtained from samples taken during a period of at least two successive years are constant and significantly better than the limits laid down in Annex I, and

(b) no factor is likely to cause a deterioration of the quality of the water.

The lowest frequency applied must not be less than 50 % of the number of samples specified in the table except in the particular case of note 6.

Note 5: As far as possible, the number of samples should be distributed equally in time and location.

Note 6: The frequency is to be decided by the Member State concerned.

TABLE B2

Minimum frequency of sampling and analysis for water put into bottles or containers intended for sale

Volume of water produced for offering for sale in bottles or containers each day (1) m^3	Check monitoring number of samples per year	Audit monitoring number of samples per year
≤ 10	1	1
> 10 ≤ 60	12	1
> 60	1 for each 5 m^3 and part thereof of the total volume	1 for each 100 m^3 and part thereof of the total volume

(1) The volumes are calculated as averages taken over a calendar year.

ANNEX III

SPECIFICATIONS FOR THE ANALYSIS OF PARAMETERS

Each Member State must ensure that any laboratory at which samples are analysed has a system of analytical quality control that is subject from time to time to checking by a person who is not under the control of the laboratory and who is approved by the competent authority for that purpose.

1. PARAMETERS FOR WHICH METHODS OF ANALYSIS ARE SPECIFIED

The following principles for methods of microbiological parameters are given either for reference whenever a CEN/ISO method is given or for guidance, pending the possible future adoption, in accordance with the procedure laid down in Article 12, of further CEN/ISO international methods for these parameters. Member States may use alternative methods, providing the provisions of Article 7(5) are met.

Coliform bacteria and *Escherichia coli (E. coli)* (ISO 9308-1)

Enterococci (ISO 7899-2)

Pseudomonas aeruginosa (prEN ISO 12780)

Enumeration of culturable microorganisms — Colony count 22 °C (prEN ISO 6222)

Enumeration of culturable microorganisms — Colony count 37 °C (prEN ISO 6222)

Clostridium perfringens (including spores)

Membrane filtration followed by anaerobic incubation of the membrane on m-CP agar (Note 1) at 44 ± 1 °C for 21 ± 3 hours. Count opaque yellow colonies that turn pink or red after exposure to ammonium hydroxide vapours for 20 to 30 seconds.

Note 1: The composition of m-CP agar is:

Basal medium

Tryptose	30 g
Yeast extract	20 g
Sucrose	5 g
L-cysteine hydrochloride	1 g
$MgSO_4 \cdot 7H_2O$	0,1 g
Bromocresol purple	40 mg
Agar	15 g
Water	1 000 ml

Dissolve the ingredients of the basal medium, adjust pH to 7,6 and autoclave at 121 °C for 15 minutes. Allow the medium to cool and add:

D-cycloserine	400 mg
Polymyxine-B sulphate	25 mg
Indoxyl-β-D-glucoside to be dissolved in 8 ml sterile water before addition	60 mg
Filter — sterilised 0,5% phenolphthalein diphosphate solution	20 ml
Filter — sterilised 4,5 % $FeCl_3 \cdot 6H_2O$	2 ml

2. PARAMETERS FOR WHICH PERFORMANCE CHARACTERISTICS ARE SPECIFIED

2.1. For the following parameters, the specified performance characteristics are that the method of analysis used must, as a minimum, be capable of measuring concentrations equal to the parametric value with a trueness, precision and limit of detection specified. Whatever the sensitivity of the method of analysis used, the result must be expressed using at least the same number of decimals as for the parametric value considered in Annex I, Parts B and C.

Parameters	Trueness % of parametric value (Note 1)	Precision % of parametric value (Note 2)	Limit of detection % of parametric value (Note 3)	Conditions	Notes
Acrylamide				To be controlled by product specification	
Aluminium	10	10	10		
Ammonium	10	10	10		
Antimony	25	25	25		
Arsenic	10	10	10		
Benzo(a)pyrene	25	25	25		
Benzene	25	25	25		
Boron	10	10	10		
Bromate	25	25	25		
Cadmium	10	10	10		
Chloride	10	10	10		
Chromium	10	10	10		
Conductivity	10	10	10		
Copper	10	10	10		
Cyanide	10	10	10		Note 4
1,2-dichloroethane	25	25	10		
Epichlorohydrin				To be controlled by product specification	
Fluoride	10	10	10		
Iron	10	10	10		
Lead	10	10	10		
Manganese	10	10	10		
Mercury	20	10	20		
Nickel	10	10	10		
Nitrate	10	10	10		
Nitrite	10	10	10		
Oxidisability	25	25	10		Note 5
Pesticides	25	25	25		Note 6
Polycyclic aromatic hydrocarbons	25	25	25		Note 7

Parameters	Trueness % of parametric value (Note 1)	Precision % of parametric value (Note 2)	Limit of detection % of parametric value (Note 3)	Conditions	Notes
Selenium	10	10	10		
Sodium	10	10	10		
Sulphate	10	10	10		
Tetrachloroethene	25	25	10		Note 8
Trichloroethene	25	25	10		Note 8
Trihalomethanes — Total	25	25	10		Note 7
Vinyl chloride				To be controlled by product specification	

2.2. For hydrogen ion concentration the specified performance characterisatics are that the method of analysis used must be capable of measuring concentrations equal to the parametric value with a trueness of 0,2 pH unit and a precision of 0,2 pH unit.

Note 1 (*): Trueness is the systematic error and is the difference between the mean value of the large number of repeated measurements and the true value.

Note 2 (*): Precision is the random error and is usually expressed as the standard deviation (within and between batch) of the spread of results about the mean. Acceptable precision is twice the relative standard deviation.

(*) These terms are further defined in ISO 5725.

Note 3: Limit of detection is either:

— three times the relative within batch standard deviation of a natural sample containing a low concentration of the parameter,

or

— five times the relative within batch standard deviation of a blank sample.

Note 4: The method should determine total cyanide in all forms.

Note 5: Oxidation should be carried out for 10 minutes at 100 °C under acid conditions using permanganate.

Note 6: The performance characteristics apply to each individual pesticide and will depend on the pesticide concerned. The limit of detection may not be achievable for all pesticides at present, but Member States should strive to achieve this standard.

Note 7: The performance characteristics apply to the individual substances specified at 25 % of the parametric value in Annex I.

Note 8: The performance characteristics apply to the individual substances specified at 50 % of the parametric value in Annex I.

3. PARAMETERS FOR WHICH NO METHOD OF ANALYSIS IS SPECIFIED

Colour
Odour
Taste
Total organic carbon
Turbidity (Note 1)

Note 1: For turbidity monitoring in treated surface water the specified performance characteristics are that the method of analysis used must, as a minimum, be capable of measuring concentrations equal to the parametric value with a trueness of 25 %, precision of 25 % and a 25 % limit of detection.

ANNEX IV

DEADLINES FOR TRANSPOSITION INTO NATIONAL LAW AND FOR APPLICATION

Directive 80/778/EEC Transposition 17.7.1982 Application 17.7.1985 All Member States except Spain, Portugal and new *Länder* of Germany	Directive 81/858/EEC (Adaptation due to accession of Greece)	Act of Accession of Spain and Portugal Spain: transposition 1.1.1986 application 1.1.1986 Portugal: transposition 1.1.1986 application 1.1.1989	Directive 90/656/EEC for new *Länder* of Germany	Act of Accession of Austria, Finland and Sweden Austria: transposition 1.1.1995 application 1.1.1995 Finland: transposition 1.1.1995 application 1.1.1995 Sweden: transposition 1.1.1995 application 1.1.1995	Directive 91/692/EEC
Articles 1 to 14			Application 31.12.1995		
Article 15	Amended with effect from 1.1.1981	Amended with effect from 1.1.1986		Amended with effect from 1.1.1995	
Article 16					
Article 17					Article 17(a) inserted
Article 18					
Article 19		Amended	Amended		
Article 20					
Article 21					

ANNEX V

CORRELATION TABLE

This Directive	Directive 80/778/EEC
Article 1(1)	Article 1(1)
Article 1(2)	—
Article 2(1) (a) and (b)	Article 2
Article 2(2)	—
Article 3(1) (a) and (b)	Article 4(1)
Article 3(2) (a) and (b)	—
Article 3(3)	—
Article 4(1)	Article 7(6)
Article 4(2)	Article 11
Article 5(1)	Article 7(1)
Article 5(2) first sentence	Article 7(3)
Article 5(2) second sentence	—
Article 5(3)	—
Article 6(1)	Article 12(2)
Article 6(2) to (3)	—
Article 7(1)	Article 12(1)
Article 7(2)	—
Article 7(3)	Article 12(3)
Article 7(4)	—
Article 7(5)	Article 12(5)
Article 7(6)	—
Article 8	—
Article 9(1)	Article 9(1) and Article 10(1)
Article 9(2) to (6)	—
Article 9(7)	Article 9(2) and Article 10(3)
Article 9(8)	—
Article 10	Article 8

This Directive	Directive 80/778/EEC
Article 11(1)	—
Article 11(2)	Article 13
Article 12(1)	Article 14
Article 12(2) and (3)	Article 15
Article 13(1)	—
Article 13(2) to (5)	Article 17(a) (inserted by Directive 91/692/EEC)
Article 14	Article 19
Article 15	Article 20
Article 16	—
Article 17	Article 18
Article 18	—
Article 19	Article 21

Appendix 5: Cryptosporidium Results

Method Ref:1215
Analysis Start Date:17.06.02

Lab. Ref. No.	Service Required	Sample Description	Date samples	Volume Sampled (L)	Volume Analysed (L)	No. of Cryptosporidial Oocysts Detected / L	No. of Giardial Cysts Detected / L
02-2583	Crypto /Giardia Analysis-10 day	Rosenallis Location: Shanbeg	30.05.02	256	256	0	0
02-2584	"	Donaghmore	31.05.02	271	271	0	0
02-2585	"	Upper Forest	04.06.02	176	176	0	0
02-2586	"	Ballybuggy	10.06.02	430	430	0	0
02-2587	"	Errill	11.06.02	376	376	0	0

Authorised By:
Mary Hyland

Report Reference: 02-2326

Lab. Ref. No.	Service Required	Customer Sample Ref.	Date Sample Taken	Volume Sampled (L)	Volume Analysed (L)	No. of Cryptosporidial Oocysts Detected / L	No. of Giardial Cysts Detected / L
02-2326	Crypto /Giardia Analysis (10 day)	Final Drinking Water Timahoe. Co. Laois	27.05.02	235	235	0	0

Method Ref: 1202

Authorised By:

Mary Hyland .

Method Ref:1215
Analysis Start Date:17.06.02

Lab. Ref. No.	Service Required	Sample Description	Date samples	Volume Sampled (L)	Volume Analysed (L)	No. of Cryptosporidial Oocysts Detected / L	No. of Giardial Cysts Detected / L
02-2583	Crypto /Giardia Analysis-10 day	Rosenallis Location: Shanbeg	30.05.02	256	256	0	0
02-2584	"	Donaghmore	31.05.02	271	271	0	0
02-2585	"	Upper Forest	04.06.02	176	176	0	0
02-2586	"	Ballybuggy	10.06.02	430	430	0	0
02-2587	"	Errill	11.06.02	376	376	0	0

Authorised By:
Mary Hyland

Appendix 6: Circular Letter L7/98

Circular Letter L7/98

3 July 1998

Protection of Drinking Water Supplies Against Contamination from Cryptosporidium

A Chara,

1. I am directed by the Minister for the Environment and Local Government to refer to Circular Letter L14/92 of 14 December 1992 enclosing Guidelines on the Action Plans to be prepared by sanitary authorities on the prevention of contamination of drinking water supplies.

2. There have been a number of instances in the UK in recent times of contamination of drinking water by cryptosporidium, a pathogen which is not covered in the current European Communities (Quality of Water Intended for Human Consumption) Regulations 1988.

3. Guidelines on minimising the risk of cryptosporidium in water supplies, prepared in consultation with the Department of Health and Children, and the Environmental Protection Agency, are circulated herewith.

4. Sanitary authorities are requested to review, in the light of the Guidelines, their Action Plans and training programmes, to cover the potential risks associated with cryptosporidium.

   This risk underlines the need for sanitary authorities to ensure that good prevention measures, including good management practices, are in place in relation to the on-going protection of drinking water supplies.

   Sanitary authorities should also ensure that good liaison arrangements are in place with Health Boards, and the Environmental Protection Agency.

5. Any queries in relation to these Guidelines may be made to either Mr. Oliver Fogarty, Engineering Inspector (Extn. 2267) or Mr. Denis O'Leary, Engineering Inspector (Extn. 2172).

Mise le meas,

Brendan Aherne,
Principal,
Water Services Section
Extn. 2331

To: Each Sanitary Authority

PROTECTION OF DRINKING WATER SUPPLIES

Guidelines for Local Authorities

on

Minimizing the Risk of Cryptosporidium in Water Supplies

Department of the Environment and Local Government 3 July 1998.

MINIMIZING THE RISK OF CRYPTOSPORIDIUM IN WATER SUPPLIES

1. Cryptosporidium in the Environment

- Description of the organism and its health effects

Cryptosporidium is a protozoan parasite found in humans, many animals and in birds and fish. The parasite multiplies in the gastrointestinal tract of the host, which then excretes the oocysts of the parasite in its faeces. The oocysts are tiny, 4-6 microns in diameter which are shed in very large numbers. Infected cattle, for example, can shed approximately 10^{10} oocysts daily for up to 14 days. As a result, contamination of the environment can reach a very high level in a short period of time.

Infection does not always give rise to symptoms. In normally healthy individuals, however, cryptosporidiosis is an important cause of self-limiting but unpleasant diarrhoeal disease. It typically gives rise to profuse watery diarrhoea with, in some cases, cramping abdominal pain, nausea, vomiting and low grade fever. In patients with suppressed immune systems, the disease can be more serious and as yet, in such cases, there is no effective treatment.

- Occurrence in the environment

Although cryptosporidial infections are widespread in animals, outbreaks of the infection usually originate from calves or lambs, and these are likely to form the most important reservoir of infection for humans.

The oocysts of cryptosporidium are very resistant to adverse factors in the environment and can survive dormant for months in cool, dark conditions in moist soil or for up to a year in clean water.

It is thought that the number of oocysts needed to cause infection is small, possibly less than 10. Cryptosporidiosis is normally transmitted by the faecal-oral route either from animal to man or person to person. Such direct transmission can occur through contact with farm animals or within families or in children's playgroups, in hospitals or other institutions. The disease is most prevalent in children aged one to five, especially those in nurseries, schools, etc.

This circular, however, is concerned with the waterborne transmission of the disease. While it is certain that cryptosporidiosis can be contracted from contaminated water, the proportion of cases which are so transmitted is not known. In the UK it is considered that the number of waterborne cases of Cryptosporidiosis comprises only a small fraction of all cases of diarrhoea. The significance of incidents which are linked to the waterborne route is that contamination of a water supply system can give rise to many cases of illness in the supply area and can cause considerable public concern.

There have been a number of outbreaks of cryptosporidiosis in the US and UK in which the disease was considered to be waterborne. While no such links have yet been established in Ireland, this is probably a reflection of under-reporting of diarrhoeal diseases generally and of a lack of epidemiological research.

It is generally considered that most oocysts found in both ground and surface waters derive from contamination through animal faeces entering water courses.

The contamination can occur through a variety of routes viz:

- Slurry tank spillage/overflow
- Cattle yard run-off
- Penetration of overburden during dry periods (ground fissured)
- Run-off associated with rainfall after manure spreading
- Wastewater treatment plant effluents
- Water treatment sludge streams
- Animal slaughtering / meat processing plants upstream of water supply abstraction points may also be a source of contamination.

In particular in water treatment plants the backwash waters are potentially a high oocyst concentration area as the filters generally retain the bulk of the oocysts.

Cryptosporidium is not covered in the current "Drinking Water Directive (80/778/EEC). As a result this parameter is not listed in the drinking water regulations, S.I. 81 of 1988, which give effect to the directive in this country.
Cryptosporidium is not included in the revised directive which is presently at draft stage, as studies are still ongoing regarding the infective dose for humans. However, in order to ensure that water intended for human consumption does not contain parasites such as cryptosporidium in numbers sufficient to constitute a potential danger to human health the revised draft directive includes the indicator organism "Clostridium perfringens (including spores)", with a note which contains the following requirement " In the case of non-compliance with the proposed parametric value of 0/100ml Member States shall investigate the supply to ensure that there is no potential danger to human health arising from the presence of pathogenic micro-organisms, e.g. cryptosporidium".

2. Water Treatment Processes

Depending on the raw water quality the level of treatment provided at a water supply source can vary from minimal treatment to the provision of very extensive treatment. Hereunder are listed the common processes encountered and a brief commentary is given in relation to the impact on cryptosporidium:

- Coagulation / Flocculation / Sedimentation and Filtration.

These processes consist of the use of coagulant and coagulant aids to form flocs which capture fine particles in the raw water. These weak flocs are usually removed by settlement followed by filtration. It is generally considered that oocysts will be caught by the floc and will be removed at settlement or filtration stage. It is possible that some oocysts, possibly a small number, may pass through these treatment stages, especially if the floc is very weak or ruptured.

- Disinfection

Disinfection of water supplies by chlorination, at current practice levels, will remove the commonly encountered pathogens and the absence of indicator organisms such as E.coli is indicative of the effectiveness of the disinfection. Cryptosporidium oocysts, however, are resistant to chlorination and, if present, will continue to remain viable and unaffected.

- Distribution Mains

Contamination of treated water may occur in the distribution network as a result of watermain leaks. In particular if mains pressure falls due to high demand then the system is at risk from groundwater borne contamination (from defective sewers, soakpits and surface contamination).

- Reservoirs

In addition contamination can occur at reservoir sites where the grassed surfaces of reservoirs are grazed (if this coincides with structural defects in the roof etc.). Poorly designed and badly maintained ventilation and access systems can also permit contamination.

- Point of use Devices

There are several point of use devices available which are either intended to produce a physical barrier against impurities or a treatment stage for specific removal of certain substances. Some units are plumbed into mains supplies: others are simply jugs fitted with filters.

- Mechanical filters may be constructed of wound textiles, microporous plastics or porous ceramics and can be effective at removing particulate matter. Removal of oocysts depends on pore size. These filters need to be replaced or cleaned regularly and care should be taken in disposing of the used elements.
- Activated carbon is commonly used in a cartridge form to improve the organic quality, including taste. Experience would suggest that this is not effective in removing oocysts.
- Ion exchange units employ a cartridge containing resin beads. It is unlikely that these would provide an effective barrier against oocysts.
- Reverse osmosis units employ a membrane system and, to be effective, would need to be maintained in accordance with the manufacturer's instructions.
- Distillation units are found in hospitals, laboratories and not in domestic properties. These are effective against oocysts but it is not recommended that distilled water be used for drinking purposes on health grounds.
- Ultraviolet radiation is as yet unproven in respect of cryptosporidium.
- Some experimental results reported suggest strongly that ozone, at the concentrations used in water treatment, inactivates oocysts. Inactivation rates of 99% are achievable with contact time values of 5-10 minutes.

3. Monitoring

Properly operated conventional treatment processes can provide a high level of protection from cryptosporidium contamination. This is indicated by current regular monitoring by the Dublin Authorities.
Although experience of cryptosporidium is limited, a number of common features have been identified from the documented outbreaks to date. The evidence suggests that certain practices may give rise to conditions which favour the passage of oocysts through a treatment plant. In particular there appears to be a risk of contamination under the following conditions:

- following agricultural pollution of source water
- following exceptionally heavy rainfall after dry spell, especially when associated with recent spreading of agricultural slurries.
- following on, or associated with major planned changes in operational practices at a treatment works i.e. bypassing of filters or severe overloading of filters.

Clearly the risk is higher for sources with minimal treatment.

While it is not feasible or practicable to undertake routine sampling and analysis for cryptosporidium for all sources, each Local Authority should formulate a monitoring strategy which clearly sets out how often monitoring will be carried out having regard to the known risks and local circumstances. Where the need for monitoring is indicated, monitoring in the first instance should be for Clostridium perfringens (including spores). Monitoring should be carried out at the tap, and, where the parametric value of 0/100ml is exceeded, follow-up monitoring for Cryptosporidium should be undertaken on both the raw and treated water. In formulating monitoring policy the Local Authority should take into account the following circumstances:

- Following exceptional contamination of water sources by agricultural pollution or sewage.
- For a transitional period when a significant planned change in a water treatment process or distribution network takes place.
- When, for exceptional operational reasons, the water treatment process is operating abnormally.
- When turbidity readings or levels of indicator or other organisms deviate from the normal ranges.
- If an outbreak of cryptosporidiosis in the community is suspected as being linked to a water supply.

If a waterborne outbreak is suspected the Local Authority will need to establish an investigative program which would concentrate on the following areas:

- The source waters.
- The surrounding catchment areas and deposits in reservoirs if there is evidence of spreading of manures.
- Treatment works including backwash water, sludge, filter beds and any recycled water.
- Local pipelines and service reservoirs, in particular, if the medical evidence suggests localisation of the outbreak
- Dead areas in the distribution network

4. Avoiding an Outbreak

Whilst cryptosporidium exists widely in nature a number of measures can be adopted which will proactively manage and minimize the potential risks of a waterborne outbreak.

1. As a threat to health only arises if an unusually large concentration of oocysts occurs in the water source, it follows that a well formulated and implemented catchment management plan (Ref: W.P. 6/97 Managing Ireland's Rivers and Lakes-A Catchment Based Strategy Against Eutrophication) can improve the level of protection.
Local Authorities have extensive statutory powers available to them under the Water Pollution Acts 1977 and 1990 and the Waste Management Act 1996 to control agricultural activities presenting a threat to water quality including manure and slurry storage and disposal arrangements, e.g. landspreading. These powers should be availed of, as appropriate, to protect water supply sources, including contamination risks arising from direct access by farm animals to rivers and lakes. Attention should also be given to the protection of groundwater sources of supply with restrictions imposed, as necessary, on agricultural practices within the immediate area of the point of abstraction and, the zone of contribution to the groundwater resource. Animal slaughtering / meat processing plants upstream of water supply abstraction points should be investigated and the local authority,or in the case of licensed activities the local authority or the EPA as appropriate, should ensure that a high standard of operation/ maintenance of wastewater treatment in such premises is achieved.

2. In the treatment of water careful attention should be paid to the following points:

- In the operation of rapid filters sudden surges of flow should be avoided which might dislodge retained solids
- rapid filters should not be restarted after shutdown without backwashing
- after cleaning, slow sand filters should not be brought back into use without an adequate "ripening" period
- by-passing of part of the water treatment process should be avoided

- Recycling of backwash water should be avoided as a precaution in times of intense rainfall or after a pollution incident
- consideration should be given to the installation of monitors to make it possible to measure the turbidity of each rapid filter to assist early detection of conditions which may favour the breakthrough of oocysts into the treated water
- the value of coagulant aids should be assessed with a view to optimizing flocculation
- All borehole linings and seals should be maintained to a high standard

3. Local Authorities should ensure that the grazing of livestock is not practiced on or near grass covered reservoirs

4. Significant leaks in the distribution system should be repaired promptly.

5. Responding to an Outbreak

Circular Letter L14/92 entitled PROTECTION OF DRINKING WATER SUPPLIES provides Local Authorities with guidelines to assist in the preparation of Action Plans. The Action Plans are in two parts a) Prevention and b) Active Response. The first part should be continuously in operation, thereby minimizing the likelihood of the activation of the second part.
Action Plans now need to be reviewed to provide for the potential risks associated with cryptosporidium. In this context, the following is a list of items that would be relevant to Part 1

- <u>Raw Water Intake</u>

  Check catchment control measures
  Use alternative sources where feasible

- <u>Water Treatment</u>

  Optimize coagulant dose and brand/type selection
  Optimize pH for coagulation
  Assess use of flocculant aids
  Ensure adequate mixing and contact time at flocculation stage
  Check operation of sludge bleeds
  Avoid sludge blanket disturbance by flow variation or by wind effects
  Downrate plant if possible to maximize particle entrapment
  Backwash rapid gravity filters as frequently as possible consistent with maintenance of throughput
  Ensure that depth of media is maintained above the minimum level, particularly on slow sand filters
  Control carefully filter start-up procedures. Run filters on slow start after return to service, or preferably run to waste until filtrate turbidity is satisfactory
  Ensure that part-used filters (both rapid and slow) are never returned to service without cleaning
  Monitor continuously or regularly turbidity of water from individual filters
  Achieve consistently lowest possible turbidity as this will minimize oocyst breakthrough
  Monitor filter headloss
  Control filter backwash cycle to ensure maximum headloss or turbidity of filtrate allowable are not exceeded
  Consider conditioning of water prior to filtration with polyelectrolyte (rapid filter only)
  Consider pre-conditioning of filter bed by addition of polyelectrolyte to final rinse of backwash water (rapid filter only)
  Divert filter backwash water and other process waste water so that it is not returned to the works without special treatment. Recycling of backwash water can return a substantial oocysts load to the headworks

Make arrangements for the safe disposal of waste process water if it is likely to be contaminated

Inspect, clean out, and ensure removal of all sludges from contact tanks

With service reservoirs inspect clean out and remove all sludges. Repair all defects (with say butyl sheets) if rain water can seep in

Introduce program of flushing and / or scouring to remove suspect water and any contaminated mains deposits from the distribution system.

As with the previous circular the Local Authority should identify alternative water supply sources and should have formal communication channels with appropriate Health Authorities and the EPA. In addition sample public information sheets should be prepared in advance which would alert the public to any possible contamination and appropriate steps to be taken (Boiling Notice, Cryptosporidium is susceptible to high temperature). The Local Authority should have arrangements made with an appropriate laboratory capable of undertaking the necessary analysis for cryptosporidium.