HOW TO KEEP OUR DRINKING WATER SAFE FROM CRYPTOSPORIDIUM

According to *The Provision and Quality of Drinking Water in Ireland: A Report for the Years 2006-2007*, published recently by the Environmental Protection Agency (EPA), Ireland has the highest incidences (13.7 per hundred thousand) of cryptosporidiosis of 16 EU member states where the disease is notifiable. Paul O'Callaghan, Process Specialist with the Response Group, explains the nature of cryptosporidiosis and some emerging technologies which can be used to help manage it.

Recent media coverage

In the wake of the *Cryptosporidium* outbreak in Galway, it was not surprising that there was an intense media spotlight on the recent EPA report on Drinking Water Quality in Ireland 2006–2007. The EPA Report concluded that "339 supplies, representing 36 percent of all public drinking water supplies require detailed profiling". The media was quick to pick up on this and any of you who picked up a newspaper in the last week of January may have read some of the following headlines based on the above:

"Over a third of our water at risk of contamination";

"More than 300 public tap water supplies – one third of the country's total - face being shut down in a major new pollution scare";

"Billions later you can have Delhi belly at home."

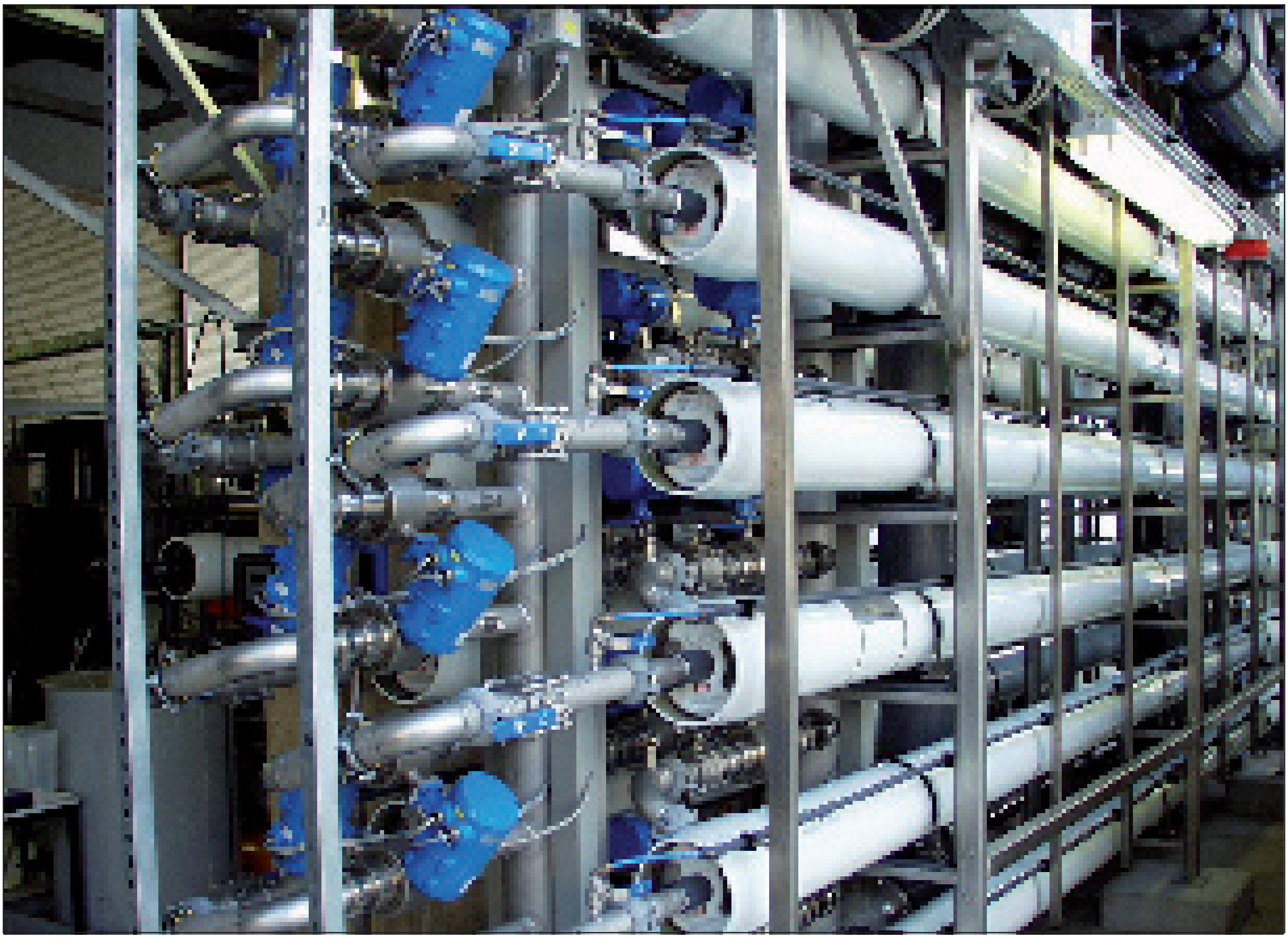
To the layperson, the newspaper headlines might be taken as implying that over one third of the Irish population was being supplied with drinking water of dubious quality. The EPA report however goes on to clarify: "it is worthy of note that the majority of exceedances in public water supplies were found in the smaller public water supplies (those serving less than 2,000 people) and the rate of compliance in the large public water supplies was 99.7%." In actual fact, the proportion of the Irish population affected by the 339 supplies on the amber list (EPA list of drinking water plants requiring further investigation) is considerably less than 36%. However, there is an equal obligation on each public water supply, regardless of the size of the population served, to meet the standards. In this respect the EPA views all supplies equally.

Cryptosporidium – an emerging pathogen

Disease-causing agents can be broken up into three groups; bacteria, viruses and protozoa. *Cryptosporidium* belongs to the third group, protozoa. The word protozoa comes from the Greek word for 'little animal'. One aspect of *Cryptosporidium* which makes it problematic from a water treatment perspective is that at one stage in its life cycle it produces small spore-like bodies known as cysts.

These cysts have a hard outer wall which makes them resistant to chlorine and they can survive for months in a cold, damp environment.

There are a number of different strains of *Cryptosporidium*, but two in particular, *Cryptosporidium parvum* and *Cryptosporidium hominis*, are responsible for most cases of human cryptosporidiosis. *Cryptosporidium hominis* is almost exclusively a human pathogen while *Cryptosporidium parvum* can be transmitted by cattle.



Membrane technology costs are decreasing.

There are a number of important points worth making in relation to *Cryptosporidium*:

1. it is a relatively new problem;
2. we do not routinely test for it;
3. faecal coloforms are not good indicators for it; and
4. chlorine does not kill it.

Cryptosporidium is a relatively new problem

Cryptosporidium is an emerging pathogen. The first cases of human cryptosporidiosis were reported in 1976. Prior to that, it was not known that *Cryptosporidium* caused illness in humans. The disease came to international attention in 1993 when an operation failure at the water treatment plant in Milwaukee, Wisconsin, led to a massive outbreak of cryptosporidiosis. An estimated 403,000 persons became ill, 4,400 were hospitalised and it is estimated that 60 people died as a result of the outbreak. It was the largest documented outbreak of water-borne disease in the United States since record keeping began in 1920. In the last decade in the US, the proportion of water-borne illness associated with protozoa has tripled over that of the previous decade.

We do not routinely test for *Cryptosporidium*

There is no requirement under the Irish Drinking Water Regulations to test for *Cryptosporidium* and it only became a notifiable disease in Ireland in 2004. Therefore, there is very little historic data available about the presence or absence of *Cryptosporidium* in drinking water supplies. In addition, unlike bacterial testing which is relatively simple, testing for *Cryptosporidium* is a complex process and there is only one laboratory in Ireland currently set up to do this testing commercially.

The fact that we do not test for it would be less problematic if faecal coliforms were a good indicator of the presence or absence of *Cryptosporidium*. However, it must be noted: faecal coliforms are not good indicators for *Cryptosporidium*. Faecal coliforms are very good indicators for the presence or absence of bacteria and viruses, but not so, for the presence or absence of *Cryptosporidium*.

In records from the USA, coliform bacteria were only detected in 49% of outbreaks where protozoa were the cause of illness.

Chlorine does not kill *Cryptosporidium*

This is a key point. For the past one hundred years chlorine has proved to be a reliable and effective disinfectant. In fact, the introduction of filtration and chlorination of drinking water has been the single biggest factor in reducing mortality rates and increasing longevity in the developed world in the 20th century.

Managing the *Cryptosporidium* risk

Anybody involved in drinking water treatment will be familiar with the multi-barrier approach. This involves catchment protection, treatment and disinfection, protection of the water distribution network, and education of stakeholders.

I would like to focus on two emerging treatment processes which are effective tools in managing *Cryptosporidium* risk: membrane filtration and ultra-violet disinfection.

Membrane filtration

It should be noted that conventional filtration techniques, sand filtration for example, are actually very effective in providing significant reductions in *Cryptosporidium*. A well-operated sand filter can achieve in excess of 99% removal of *Cryptosporidium* cysts.

Depending on the risk in the catchment, this in itself may provide adequate protection against *Cryptosporidium*. A relatively new filtration technology, membrane filtration, is currently gaining widespread acceptance and is particularly useful in protecting against *Cryptosporidium*.

To date, membrane filtration has been regarded as an expensive technology and has not been widely adopted in Ireland. However, membrane costs are decreasing and membrane filtration is now very commonplace in North America. There are two points worth noting here in relation to membrane filtration.

Firstly, final water quality is independent of influent water quality and, secondly, an intact membrane provides an absolute barrier against *Cryptosporidium*.

The fact that final water quality is independent of influent quality can be of benefit for supplies in Ireland which experience sudden deteriorations in raw water quality in response to intense or prolonged rainfall events. The rate at which water can be treated may reduce due to increases in suspended solids, but the final quality of the water should not be impacted. The second point is that an intact membrane provides an absolute barrier against *Cryptosporidium*. In tests conducted on ultrafiltration membrane systems, removal efficiencies of 6–7 log reductions were recorded.

This equates to 99.9999–99.99999 removal.

The word 'intact' is very important in relation to membrane systems. An intact membrane is an absolute barrier, but that barrier is very thin, typically only 1mm thick, and if there is a breach or tear in it, then cysts and other pathogens can break through. In a membrane system there can be hundreds of thousands of hollow fibres.

One of the challenges with this technology is how to detect if one or more of those fibres have a tear.

This is an area of on-going research and it is the opinion of many in the membrane field that an integrity test with sufficient resolution to detect virus-sized breaches will be developed within the next 10 years, even if it is not initially economical or commercially viable.

Ultraviolet light (UV) disinfection

The next step following filtration is disinfection. Chlorine has long been adopted as the disinfectant of choice and will

Drinking water quality provides a major focus of discussion for Parallel Session 1 at this year's Engineers Ireland Annual Conference. See the Annual Conference preview in this issue's centre pages for further details.

continue to be used to provide a chlorine residual to protect the network. However, ultraviolet light is an emerging disinfection technology which is gaining more widespread acceptance in recent years, particularly in the context of providing protection against *Cryptosporidium*.
Three points worth noting in relation to this technology are:

- *UV does not kill pathogens, it inactivates them*
  Ultraviolet light damages the DNA of host organisms thereby preventing them from replicating. It does this in much the same way as it causes skin cancer in humans.
- *The effectiveness of a UV system is highly dependent on the transmissivity of the water*
  A UV system will only work if the UV light can pass through the water and make contact with the bacteria and other pathogens passing by the lamp. The presence of suspended solids, dissolved organic matter and iron among other things, will all affect the performance of a UV system. This is why filtration is vital to the effectiveness of a UV system.
- *Independent validation of UV systems is crucial*
  In Europe, UV systems are typically validated to the German DVWG standard. If a system is not validated to a recognised standard by an independent body, then don't use it.

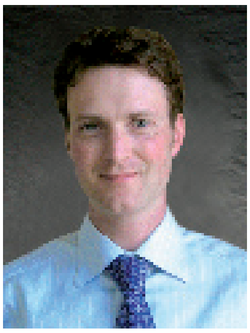
Given the recent focus on *Cryptosporidium*, should every water supply system have a UV disinfection system? This decision should be risk-based. The US EPA, for example, has created what they call a 'bin' system where they group different water supplies according to different numbers of *Cryptosporidium* cysts present in the raw water supply. Based on this, they then specify an appropriate level of treatment.

What lies ahead?

One of the media headlines quoted at the start of this article reported that 'billions later you can have Delhi belly at home'. This is presumably in reference to the fact that, despite the massive investment in water infrastructure, there are still problems. There has certainly been significant investment in water infrastructure in Ireland in the past number of years and there is 99.7% compliance in our larger public water supplies.

The new powers of the EPA in relation to the enforcement of drinking water regulations will help to highlight areas which need improvement and set these as priority areas for investment by local authorities.
While Group Water Schemes have proven to be very successful in bringing drinking water to small communities, it has long been recognised that this is an area which needs further improvement and upgrading. The ability to bundle a number of these group schemes together and tender it as one design build and operate contract is providing economies of scale and helping to provide a mechanism to upgrade these systems. ⏀

This article is based on a presentation which Paul O'Callaghan gave recently at the Engineers Ireland headquarters at Clyde Road. A complete copy of the presentation, along with overhead slides, is available for download at www.engineersireland.ie/sectors/waterandtheenvironmentalengineeringsociety/papers



Paul O'Callaghan is an environmental process specialist and holds a Masters degree in Water Resource Management. He is the author of numerous papers on water and wastewater treatment and lectures on Environmental Protection technology at Kwantlen University College. He is currently chair of a technical committee on decentralised wastewater management in British Columbia and is keenly involved in environmental technology development and the Clean Tech industry. Paul is based in Vancouver, Canada. He is an Associate Member of Engineers Ireland.