



TECHNICAL NOTE

2 – Faecal contamination

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If a pool is contaminated with faeces, the pool operator must decide quickly on an appropriate course of action in order to prevent any possible illness in users. This is particularly important with diarrhoea, which may contain the chlorine-resistant organism *Cryptosporidium* ('Crypto'). So it is crucial to be prepared. It is also important to do everything possible to prevent such contamination in the first place – see the Prevention section of this Technical note.

Preparation

Operators need to be aware of the potential health risks and have the necessary procedures, equipment and chemicals in place and accessible at all times. All pools should have a written procedure, as part of their emergency action plan, stating what action to take in the event of a faecal incident. Staff must be trained in these procedures, and the training recorded. There should also be a schematic drawing of the installed water treatment, which is vital for the informed operation of the pool and in the investigation of problems including outbreaks of infectious disease.

Operators should follow the PWTAG Code of Practice (on www.pwtag.org).

Dealing with a faecal incident

If faecal contamination has only been reported, and there is some doubt about the accuracy of the report, its presence should be confirmed by pool staff. If it cannot be confirmed, pool operators must assess the risk and may decide that the risk of harmful contamination is low and allow bathing to continue. This assumes that pH and disinfection are within normal limits. Pools should maintain a faecal accident log.

All faeces contain potentially harmful microorganisms. The actual risk to pool users depends on whether the faeces are solid or runny.

Solid faeces

Solid faeces are relatively easy to deal with. It is unlikely that the perpetrator is suffering from an acute gastrointestinal illness. And the microorganisms in it are relatively contained.

1. The stools should immediately be removed from the pool using a scoop or fine mesh net and flushed down the toilet (not put in any pool drains).
2. There must be certainty that all the faeces have been captured and disposed of. If not, and there is possible widespread distribution of the faeces in the pool, then the pool should be closed and the advice below for runny faeces considered.



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3. All equipment that has been used in this process should be disinfected using a 1% solution of hypochlorite.
4. If the pool is operating properly with appropriate disinfectant residuals and pH values, no further action is necessary.
5. Depending on the extent of the contamination, how public it has been, and how quickly it can be dealt with, operators should consider clearing the pool of bathers for, say, 30 minutes while steps 1-4 are negotiated. This is certainly necessary if the faeces has broken up. Bathing should not resume until all the faeces have been removed.

Runny faeces

If the stool is watery, runny or soft (something like diarrhoea), the risk of infection is greater: the perpetrator is more likely to be carrying enteric pathogens, and if so they are likely to be spread through the pool water. It will certainly be impossible to remove the faecal material as it is with solid stool.

The infectious causes of diarrhoea include **viruses, bacteria and protozoa**. (Other causes include alcohol, emotion, diet and medicine side effects.) Most bacteria and viruses that cause diarrhoea – *E coli*, *Shigella*, norovirus, for example – are killed within minutes in a satisfactorily disinfected pool water. But if the diarrhoea contains oocysts of the chlorine-resistant protozoa *Cryptosporidium*, normal levels of chlorine will not be effective. Crypto is a significant cause of relatively serious gastroenteritis, particularly in pools. Young children are both the likeliest sources of the infection, and those worst affected (along with the immunocompromised).

Investigations of outbreaks linked to pools frequently reveal inadequate design and management issues, which would have made the pool vulnerable to an outbreak following contamination with diarrhoea.

In most cases of diarrhoea in a swimming pool, the operator will not know if Crypto is involved. So the safest option is to assume that it is and immediately close the pool. There are in principle three procedures that will in time remove Crypto – coagulation/ filtration, UV and superchlorination. The procedures to be followed primarily depend on the efficiency of the pool's filtration. These procedures are endorsed by Public Health England and the national *Cryptosporidium* Reference Unit which is part of Public Health Wales.

Pools with medium-rate filtration (up to 25 metres per hour)

This should include most public pools. Here the main emphasis is on filtration, which if effective should remove some 99% of the *Cryptosporidium* oocysts in each pass of pool water through the filter.



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Coagulation is critical in this: it should be continuous, and the residence time (that between the injection of coagulant and treated water reaching the filter) must be long enough for flocculation to happen – at least 10 seconds at a flow velocity no more than 1.5m/sec. Secondary disinfection (UV or ozone) and superchlorination are also relevant – see below.

How long it takes for all the pool water to pass through the filter will depend on two factors. First is the pool hydraulics – crucially, how well mixed the pool water is. Dead spots will delay the passage of all the pool water through the filters. The second factor is the turnover period – the length of time it takes for a volume of water equivalent to the pool water volume to go from pool to plant room and round to the pool again. It might take as long as 24 hours for all the pool water to pass through the filters – based on the 3 to 4-hour turnover period common to many pools.

This, then, is the procedure.

1. Close the pool – and any other pools whose water treatment is linked to the fouled pool. If people transfer to another pool, perhaps from a teaching pool to a main or leisure pool, they should shower first using soap and water.
2. Hold the disinfectant residual at the top of its set range for the particular pool (eg 3.0mg/l free chlorine if the range is 1.0 to 3.0mg/l) and the pH value at the bottom of its range (eg pH 7.0-7.4). This will maintain the normal level of microbiological protection.
3. Ensure that the coagulant dose is correct – for continually dosed PAC, 0.1 ml/m³ of the total flow rate.
4. Filter for six turnover cycles (which may mean closing the pool for a day). This assumes good hydraulics and well maintained filters with a bed depth of 800mm and 16/30 sand. This applies also to pools with secondary disinfection.
5. Monitor disinfection residuals throughout this period
6. Vacuum and sweep the pool. Cleaning equipment, including automatic cleaners, should be disinfected after use. This will at least move faecal contamination off surfaces and into the main pool water circulation, for eventual removal.
7. Make sure the pool treatment plant is operating as it should (filters, circulation, disinfection)
8. After six turnovers, backwash the filters.
9. Allow the filter media to settle by running water to drain for a few minutes before reconnecting the filter to the pool.
10. Circulate the water for 8 hours. This will remove any remaining oocyst contamination of the pool and allow the filters to ripen. It is optional, depending on the pool operator's confidence in backwashing procedures.
11. Check disinfection levels and pH. If they are satisfactory re-open the pool.
12. Any moveable floors and booms should be moved around from time to time during the whole process.



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Pools with high-rate filtration (over 25 and up to 50 metres per hour)

High-rate filters do not filter *Cryptosporidium* oocysts, or anything else, as well as medium-rate filters. But because many pools have them, it is important to know how to deal with faecal contamination.

The main emphasis is on superchlorination (see also below and the PWTAG technical note on superchlorination). High-rate filters without coagulation remove as little as 10% of *Cryptosporidium* oocysts in each pass. Even with coagulation, and perhaps 50% removal, it could take two days to be safe.

The procedures below also apply to tier filters.

1. Close the pool – and any other pools whose water treatment is linked to the fouled pool. If people transfer to another pool, they should shower first using soap and water.
2. If coagulation is not the norm, a supply of polyelectrolyte coagulant should be available so it can be hand-dosed in these circumstances, following manufacturers' instructions.
3. Superchlorinate to 20mg/l adjusting the pH to 7.2-7.4 and leave for 13 hours (or 50mg/l for 5 hours). Procedures and supplies must be in place for this (see PWTAG Technical note on superchlorination).
4. Vacuum and sweep the pool.
5. Make sure the pool treatment plant is operating as it should.
6. Backwash the filters.
7. Allow the filter media to settle by running to drain for a few minutes (rinse cycle) before reconnecting the filter to the pool.
8. Reduce the free chlorine residual to normal by dilution with fresh water or using an approved chemical. This may mean using the chemical gradually; procedures and supplies must be in place for this. See the Technical note on superchlorination for details.
9. When the disinfectant residual and pH are at normal levels for the pool, re-open.
10. Superchlorination should remove any current contamination but will not guarantee future water quality. So it is important to review procedures for the control and removal of contamination by Crypto.

Pools with no filtration (fill and empty pools)

Here there is the possibility of emptying the pool altogether. This might apply to a paddling or plunge pool, for example. For any pool, if operators are confident that they can safely empty the pool, this is the procedure that should be followed.

1. Close the pool – and any other pools whose water treatment is linked to the fouled pool.
2. Superchlorinate the pool to 20mg/l for 13 hours or 50mg/l for 5 hours.
3. Vacuum and sweep the pool.
4. Drain, rinse and refill.
5. Re-treat and when disinfectant residual and pH are at normal levels for the pool, reopen the pool.



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Pre-coat filters (including regenerative media filters)

1. Close the pool, and advise bathers to shower. If people transfer to another pool, they should shower first using soap and water.
2. Superchlorinate to 20mg/l adjusting the pH to 7.2 to 7.4 and leave for 13 hours during this time the chlorine and pH should be checked every 2 hours and maintained at the above levels. Alternatively, the pool can be super-chlorinated to 50mg/l for 5 hours, adjusting the pH to 7.2 to 7.4. Procedures and supplies must be in place for this (see PWTAG Superchlorination Technical note 23). Continue to circulate the pool water at its designed 'normal flow rate' through the pool and treatment system. Vacuum and sweep the pool.
3. Reduce the free chlorine residual to normal by using an approved chemical e.g. sodium thiosulphate, or if the pool is small by dilution with fresh water. This may mean using the chemical gradually; procedures and supplies must be in place for this. (See PWTAG Superchlorination Technical note 23 for details.)
4. The filter should be bumped, drained, and rinsed to remove all the media from the filter. This may take 2-3 rinse cycles depending on the condition of the wands/septums. If the filter is due a manual (or chemical clean) clean it should be done at this point. Recharge the filter with media as per the manufactures instructions. It is important that operators use only the grade of filter medium recommended by the manufacturer.
5. Allow the pool to circulate for one turnover, then complete a manual bump cycle.
6. When the disinfectant residual and pH are at normal levels for the pool, re-open.

Superchlorination should deal with microbial contamination but will not guarantee future water quality, it is essential to ensure that filters are regularly regenerated, degreased and maintained in accordance with the manufacturer's instructions for this to be achieved. Chemical reserves should be maintained within the correct operating ranges.

Ceramic membrane filters

Ceramic filters are a way of achieving microfiltration – removing bacteria and anything bigger, including *Cryptosporidium*.

1. Close the pool – and any other pools whose water treatment is linked to the fouled pool. If people transfer to another pool, perhaps from a teaching pool to a main or leisure pool, they should shower first using soap and water.
2. Hold the disinfectant residual at the top of its set range for the particular pool (e.g. 3.0mg/l free chlorine if the range is 1.0 to 3.0mg/l) and the pH value at the bottom of its range (e.g. pH 7.0-7.4). This will maintain the normal level of microbiological protection.
3. Make sure the pool treatment plant is operating as it should (filters, circulation, disinfection).



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4. Filter for six turnover cycles with no bathers in the pool, at the full system design flow rate. This assumes good hydraulics and well-maintained filtration technology. This applies also to pools with secondary disinfection.
5. Maintain automatic flushing throughout the six turnover periods. It is recommended that at least four-flushing cycles are completed during this period, regardless of differential pressure parameters.
6. Monitor disinfection residuals throughout this period.
7. Vacuum and sweep the pool. Cleaning equipment, including automatic cleaners, should be disinfected after use. This will at least move faecal contamination off surfaces and into the main pool water circulation, for eventual removal.
8. For deck-level pools, remove transfer channel grating and jet wash internal faces of the channel.
9. After six turnovers, do a full clean in place (CIP) of the filtration system using the alkali detergent recommended by the manufacturer. The CIP should include a flush before and after, to ensure all particulate is removed from the membranes.
10. Check disinfection levels and pH. If they are satisfactory re-open the pool.
11. Any moveable floors, booms or hydraulic disabled platforms should be operated from time to time during the whole process.
12. Any water features or aerosol sprays linked to the contaminated pool must also be operated regularly during the process to ensure there are no stagnant pipelines.

Cartridge filters

1. Close the pool and advise bathers to shower using soap and water.
2. Continue to circulate the pool water through the pool and treatment system. Superchlorinate to 20mg/l adjusting the pH to 7.2 to 7.4 and leave for 13 hours (or 50mg/l for 5 hours). Procedures and supplies must be in place for this (see PWTAG Superchlorination technical note 23). Vacuum and sweep the pool
3. The cartridge filter should then be removed and disposed of.
4. Reduce the free chlorine residual to normal by dilution with fresh water or using an approved chemical. This may mean using the chemical gradually; procedures and supplies must be in place for this. (See the Technical note 23 on superchlorination for details).
5. Install a new cartridge filter.
6. Allow the pool to circulate for one turnover.
7. When the disinfectant residual and pH are at normal levels for the pool, re-open.

Superchlorination should deal with microbial contamination but will not guarantee future water quality. So it is important to regularly clean and or replace the cartridge filters and maintain chemical reserves within the correct operating ranges.



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Water features

If a pool is closed for six turnovers after faecal contamination, the circulation should include any water features, which should be kept running. The same applies if superchlorination (see below) is employed.

Secondary disinfection

Secondary disinfection using UV is strongly recommended by PWTAG – partly to counter the threat from *Cryptosporidium* and partly for its other water quality benefits, including allowing pools to operate with lower disinfectant residuals. UV plus good coagulation and filtration provides a multi-barrier defence against *Cryptosporidium*.

All pools should do a risk assessment to determine whether secondary disinfection is required. The risk assessment should take into account the hydraulic and filter characteristics of the pool, as well as the risk from routine unseen contamination. It is particularly recommended for hydrotherapy pools and pools used by young children. Their users are likely to be more vulnerable to – and to be carriers of – *Cryptosporidium*.

Where used, UV should be applied to the full flow and be capable of a 3log (99.9%) reduction in viable *Cryptosporidium* oocysts. UV installations should be medium pressure, 60mJ/cm² and monitored to ensure an effective dose rate.

PWTAG's book, *Swimming Pool Water*, has more details about UV (and ozone) use.

Superchlorination

The US Centers for Disease Control (CDC) recommends high chlorine concentrations alone (eg 20mg/l for 13 hours) to inactivate *Cryptosporidium* if any swimming pool is contaminated.

In practice, many pools would find achieving and maintaining such residuals difficult with standard dosing equipment. Then there is the possibility of generating unwelcome disinfection byproducts as a result. And finally there is the challenge of reducing residual levels afterwards – either chemically or by water replacement. The effectiveness of this approach is difficult to monitor, and is no quicker than the coagulation and filtration method above. Coagulation, filtration and backwashing are certainly also needed. And any UV (or ozone) plant should be switched off and by-passed during superchlorination. Operators may wish to consider superchlorination, either on its own or alongside PWTAG's filtration method – belt and braces. Operators should be confident that the pool plant, including valves etc, will withstand superchlorination.

There is a PWTAG Technical note with details of superchlorination and dechlorination.



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Prevention

Because pool operators are unlikely to know what the cause is of any contamination with diarrhoea, and because it can get into a pool unnoticed, the best defence against infections including **Cryptosporidium** is good **Hygiene** (*Swimming Pool Water* chapter 3), **Hydraulics** (chapter 6) and **Filtration** (chapter 7). Secondary disinfection with UV is a good second line of defence.

Investigations of Crypto outbreaks linked to pools frequently reveal inadequate design, operation and management issues which would have made the pool vulnerable to an outbreak following contamination with diarrhoea. Attention to these issues is vital.

Prevention can be summarised.

- Control entry using notices at reception saying that people with diarrhoea must not swim – then, or for 48 hours afterwards. Those who have been diagnosed with cryptosporidiosis must not swim for 14 days after diarrhoea has stopped, as infective *Cryptosporidium* oocysts can still be released in that period. If an outbreak of cryptosporidiosis has been identified, it may be that some regular bathers will have had diarrhoea, but not had the illness diagnosed. They too should be excluded from the pool for a fortnight after symptoms have stopped.
- Encourage bathers to wash and shower before swimming. Someone who has recovered from cryptosporidiosis could still have oocysts around their anus. Pre-swim showering is good for water and air quality in any case, as it minimises combined chlorines.
- Encourage bathers to use the toilets before they swim, and wash their hands afterwards. Children should be offered frequent toilet breaks.
- Young children should ideally have their own pools. There should be good baby changing facilities, and babies should wear special swimming nappies (but not swim if they have diarrhoea). There should be provision for safe disposal of soiled nappies.
- Continuous low-level dosing of a coagulant is recommended for all pools to improve the filtration efficiency and increase the removal of any contaminants from the pool. This procedure significantly reduces the risk associated with any unseen faecal release.
- Backwashing protocol is critical; when neglected, for example, it can be a factor in outbreaks of cryptosporidiosis. Backwashing must not take place when the pool is being used and should be done at the end of bathing for the day, normally in the evening. This is because after backwashing and rinsing it can take several hours for the filter to fully ripen – a process whereby the media settles back down and re-compacts to provide an efficient filtration system. Repeated backwashing throughout the day when the pool is in use is therefore wrong.
- Backwashing of medium-rate filters should be done at least once a week or more frequently as the filter pressure differential dictates and according to the manufacturer's literature for the filters installed.



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- Avoid high-rate filters if possible. If they are in place, they may need to be backwashed more often than once a week (as the pressure difference dictates) but this should never be more than once a day, and only when bathing has finished for the day.
- Ensure there is an effective disinfectant residual, and an appropriate pH, at all times.
- The pool hydraulics should ensure appropriate turnover periods and good mixing of water in the pool; short circuits and deadlegs should be avoided.