Trichloramine and Asthma in Swimming pools & spas Problem solved

By Dr.Howard T Dryden
October 2006

In recent years there have been many reports in the press regarding trichloramine and its potential implications as a precursor for causing occupational asthma and asthma among children. However as yet there has been no published mechanism why trichloramine is produced or a means of solving the problem. To-date there have only been alarmist negative reports. This paper serves to illustrate and present a solution to the problem.

Trichloramine production and bacteria levels

From German DIN standards 19643 “Conditioning Swimming Pool Water” chloramine production is a function of the pH of the water according to the following equations;

$NH_3 + HOCl$	>	$NH_2Cl + H_2O$	pH = 6-8	=	Mono-chloramine
$NH_2Cl + HOCl$	>	$NHCl_2 + H_2O$	pH = 5-6	=	Di-chloramine
$NHCl_2 + HOCl$	>	$NCl_3 + H_2O$	pH = <5	=	Tri-chloramine

According to the above equations trichloramine production occurs predominantly below a pH 5. However swimming pool water will normally have a pH between pH6.8 and 7.6, so how can di and trichloramine be produced? Certainly trichloramine can not be produced in the water because the pH is too high, however every surface in contact with pool water will have a thin biofilm, and within the biofilm the pH of the water will be acidic. Trichloramine production therefore takes place on every surface in contact with the water that has a biofilm and the thicker the biofilm the greater the production.

The single largest surface area in any swimming pool or spa is the sand filter. Every cubic meter of sand will have a surface area in the order of 3000 square meters. We have known for many years that sand acts as an excellent substrate for the growth of bacteria, and that new sand will become colonized by a range of bacterial species in a matter of a few days. The alginate bond between the bacteria and a surface can form in less than 30 seconds. In addition, the bacteria will continue to excrete alginates as a protective mechanism against oxidation by chlorine. The levels of chlorine used in most swimming pools and spas will not affect the growth of bacteria on the sand, or indeed any surface in contact with the water.

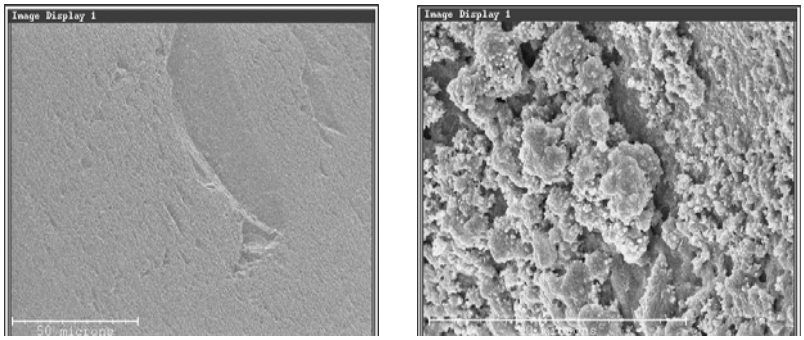

Fig 1. New sand showing no bacteria and sand after a few days showing almost a 100% cover by bacteria

Fig 1 shows that within a few days, new sand has become colonised by bacteria. The bacteria film (biofilm) develops on the sand as well as on every other surface in contact with the water. As the biofilm develops it becomes thicker and more stable. Eventually the alginates excreted by the bacteria start to glue the sand grains together which leads to channelling of water through the filter bed. This situation normally takes one to two years, although in heavily loaded systems such as spas, the high levels of organics acts as a food source for the bacteria, and coagulation of the sand can occur after a few months.

The thicker the biofilm, the lower the pH in the biofilm which in turn leads to more dichloramine and trichloramine production. There is therefore a direct correlation between system loading, organic content in the water, bacterial biomass and trichloramine production. Good hygiene, system design and operation all have a major role to play. The biomass of bacteria in a swimming pool sand filter can be as high as 5% of the total weight of the sand. The health protection Agency 2004, reported that "[1]*Out of 88 premises, 23 spa pools were found to contain legionella bacteria. Sixteen of these had passed current accepted levels for routine microbiological parameters. Bacteria may be present in high numbers, even although routine microbiological and safety checks appear satisfactory"*

Chlorine will not affect the bacteria with the biofilm in the sand filter but it rapidly oxidises bacteria when they are washed out of the filter. However there is a short period when viable bacteria will enter the pool and this occurs for about 1 hour after back-washing a filter. Periodically the filters will also become unstable, and high levels of bacteria can again be discharged making the pool water cloudy, this can happen every few weeks or months depending on the bather loading.

Many of the water quality issues in swimming pools can be related to the sand filters and the biofilm that develops on the sand. A properly designed, purged, and well managed system can work well, but fundamentally sand is an excellent substrate for bacteria. At Dryden Aqua we use fluidised beds of sand as biological filters for waste water treatment, we can therefore categorically say that no amount of back-washing of sand will remove the bacteria, so a sand filter will also be a source of trichloramine production.

[1] Press Release 14 September 2004 Health Protection Agency conference highlights spa pools as a cause of legionnaires' disease

AFM an Active Filter Media

At Dryden Aqua with financial support from the EU Life Environment program, we developed AFM (Active Filter Media) as a direct alternative to filter sand. The media actively resist bacteria development, and on average the bacterial levels on AFM are a 1 million times lower than in an equivalent sand filter. Changing the sand to AFM media makes a huge difference to the quality of the water and the production of trichloramine, ***but this is not the full story***.

Flocculation and food for bacteria

Bacteria can grow at a tremendous rate in water above 25 deg C, on average the doubling time will be around 60 minutes. This means that one bacterium can become 8 million after 24 hours, and after 48 hours the biomass of bacteria could increase to 140Kg. Clearly this does not happen in swimming pools because the food supply is limiting. However it explains why pools with a heavy bather load, or spas experience problems with the sand after a few months. If the food supply can be reduced then the growth rate of bacteria can be slowed down. It is essential that bathers have a good shower before entering the pool, the makeup mains water supply may need to be filtered to remove phosphates and organics and no surfactants or cleaning agents should be allowed to enter the pool.

The performance of the filters also needs to be optimised to achieve maximum removal of organics. This can be achieved by employing efficient coagulation and flocculation to remove the dissolved components as well as the fine solids. Aluminium based flocculent or their equivalent may be used in swimming pools. The efficient use of coagulation and flocculation will reduce the food available to the bacteria, which will slow down bacteria growth and minimise trichloramine production.

Optimise filter performance

AFM filtration will reduce the bacterial growth within the filter bed, however bacteria can also develop on the solids removed by the filter. It is therefore important to backwash the filters, even although the pressure differential across the filters does not warrant a backwash. The growth of bacteria on the collected solids is so rapid that it will start to impact on water quality after just one week. Ideally the filters should be back-washed once each week, with two week cycles as the absolute limit.

The performance of all filter media, be it AFM, sand or other substrates varies inversely proportionally to the flow of water passed through the bed. The slower the flow the better the performance. Ideally the flowrates for swimming pools should be limited to a rate less than15 cubm/hr of filter bed surface area. It is just as important to insure that all of the collected solids are removed during the backwash. If solids remain in the filter, they simply act as a food source for bacteria, and trichloramine levels will start to increase. In order to insure thorough cleaning, the filters should be air scoured at a rate between 70 and 90 cubm/hr/sqm for a period of 5 minutes before a backwash. The backwash rate should also be at a flow that expands the bed by at least 15%. In order to achieve this expansion using AFM or sand, a water flow of between 40 and 45 cubm/hr/sqm is required. Few swimming pools operate their sand

filters in this manner, which is unfortunate because it makes a huge beneficial impact on water quality.

NoPhos trace nutrient control

Irrespective of the type of media used and the efficiency of the backwash, you can not eliminate all of the bacteria. We also know that at normal swimming pool levels, chlorine will not oxidise the bacteria on the sand, pipework, pool tiles or any surface in contact with the water. Chlorine dioxide is more effective than chlorine and several products are now available to the swimming pool industry. At Dryden Aqua we are biologists and for many years we have been controlling bacteria levels in aquatic systems, not by trying to kill the bacteria but by eliminating their food source. All bacteria require certain trace nutrients, and if you remove the trace nutrients from the water, you stop bacteria in their tracks. Dryden Aqua has developed a product called NoPhos that removes the phosphate and trace minerals to form and insoluble precipitate that is then removed by the filters. When NoPhos is used, not only is the algae growth stopped, but bacteria growth rates slows down, and actually start to decline.

The combination of AFM to eliminate biofilm in the filters, flocculent to remove the bacteria food supply and NoPhos to remove bacteria trace nutrient can effectively eliminate bacteria from swimming pool and Spa systems. By elimination of the bacteria, we prevent the acid biofilm layer developing on the pool surfaces, and hence we eliminate or greatly reduce trichloramine production.

Operating a pool in the manner described in this report will greatly improve water quality and the appearance of the water. The chlorine demand of the system drops and water chemistry will become more stable, indeed the system becomes very easy to operate and manage.

UV a further refinement

UV irradiation of water is effective at reducing the combined chlorine level and in killing bacteria. The process is effective because the wavelength of light normally used is 254nm which chops up protein molecules such as DNA at the centre of bacteria. One molecule may be broken up into 10 separate smaller organic molecules, and each one then reacts with chlorine, so instead of reducing chlorine reaction products, UV irradiation of the water can actually increase the levels. The combined chlorine is partially converted to volatile Trihalomethanes (THM`s), which are then lost to atmosphere. In drinking water the maximum acceptable level is 100 ug/l, in swimming pools the recommendation is that levels should be much lower, the German DIN standard state a maximum level of 20 ug/l.

[2]Ole Bisted, from Danish Technological Institute Department for Swimming Pool Technology, reported that UVc light is used, activated carbon should also be applied in order to reduce the dissolved organics and THM`s. However if you use activated carbon, you also remove chlorine, a biofilm develops on the carbon and you produce

[2] Presented at the School of Water Sciences 1 day conference on Swimming Pool Water Quality and Treatment 2002 Cranfield University, ISBN 1 86194 020 3

trichloramines. The only way in which you can use carbon would be change the media every one to two weeks, which is not practical, or you can dose the system with powdered activated carbon, which is effective, but it can be messy and easy to get wrong. The alternative is to only use UV in pools that already have a low dissolved organic content and to tune the UV unit, not for disinfection but for the oxidation and removal of any dissolved components which were not removed by the filtration system. This is the only approach you can apply if you want to minimise THM production and avoid the use of activated carbon filtration and trichloramines.

The optimum wavelength for killing bacteria is 254nm, but UV systems are now available, which operate on different wavelengths and are much more effective at eliminating dissolved organics. The UV systems can oxidise organics back to carbon dioxide so that they no longer take part in any chlorine reaction. UV therefore becomes a useful refinement to a properly managed water treatment system not just a means of camouflaging a problem.

Chlorine

There will always be a place for chlorine, or a fast acting broad-spectrum disinfectant to prevent horizontal transmission of infectious organisms between bathers in the pool. Chlorine is still the best and most efficient disinfectant and it is likely to remain so for many years. The procedures detailed in this report eliminate the negative effects of chlorine and provide us with a way forward for the swimming pools water parks and the leisure industries.

Notes on Dryden Aqua

Dryden Aqua is consultants and manufacturers of equipment and systems for water and wastewater treatment. The industries covered include,

Industries

- Swimming pools & water parks
- Public aquarium and aquaculture
- Drinking water systems
- Waste water treatment and industrial water treatment
- Environmental systems of lake and pond remediation

Key products manufactured by Dryden Aqua;

- AFM active filter media
- NoPhos for trace nutrient control , algae and bacteria elimination
- Pressure sand filters, modified to exceed German DIN standard
- UV system for the elimination of organics & disinfection
- Chlorine and chlorine dioxide generators

Internet information on Dryden Aqua;

www.DrydenAqua.com
www.Ozone.co.uk
www.AFM.eu