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RE: Scientific opinion on efficacy of Copper Silver Ion Disinfection system used in Enviroswim ES3 pool disinfection system.

I have been researching the scientific literature on the history and efficacy of pool disinfection systems on behalf of Enviroswim. This has involved a detailed search of the scientific literature for information regarding the disinfection capability of a range of disinfection systems, notably halide based disinfectants (chlorine and bromine-based disinfectants), ozone, Ultraviolet light and silver:copper ions. The study also involved the investigation of the capability of each disinfection system for maintaining an appropriate water quality in swimming pools.

The literature has provided considerable information that chlorine and bromine-based disinfectants are capable disinfectants for the inactivation of most microorganisms with the notable exception of *Cryptosporidium* oocysts. Chlorine and bromine also can maintain a disinfection residual in the pool water after it has passed through the filtration and treatment plant. It was determined, however, that the information on the removal rates of different microorganisms exposed to chlorine and bromine provided in the scientific literature is commonly based on data from investigations using buffers that controlled pH and temperature and that were undertaken in the absence of organic compounds or sunlight. There is very little data in the literature on the disinfection effectiveness of chlorine and bromine on microorganisms in swimming pools under real world conditions.
The effectiveness of chlorine and bromine as disinfectants are well documented to be impacted by pH and temperature with optimal disinfection efficiency reducing as the pH moved from a neutral pH. Also, as water temperatures increase, chlorine concentrations can decrease due to volatilisation. Both chlorine and bromine are also photodegraded by sunlight. For chlorine -based systems this requires the addition of cyanuric acid as a stabiliser in outdoor pools. Cyanuric acid, however, has a documented impact of decreasing the disinfection capability of chlorine requiring increased chlorine concentrations in pool water to achieve similar disinfection capabilities.

Chlorine and bromine also interact with organic compounds present in pool water reducing the effective disinfection concentrations unless the concentrations of chlorine/bromine are continually maintained. This is an issue for commercial pools that can have heavy bather loads which introduce increased levels of organic compounds into the pool water. In fact, many of the non-protozoan disease outbreaks reported in the literature linked to the use of swimming pools are due to poor maintenance or operation of chlorine disinfection systems.

As well as organic compounds decreasing the effective concentration of chlorine and bromine disinfectants, there is considerable information in the scientific literature on the production of a wide range of disinfection byproducts through the interaction of chlorine and bromine with organic compounds in the water. A number of these disinfection byproducts are known or suspected of causing immune response conditions such as asthma or being carcinogenic or mutagenic. It has also been reported that some chorine-based disinfection byproducts may have potential effects on the endocrine system of young male swimmers.

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The scientific literature reporting the disinfection capability of ozone and ultraviolet light (UV) in swimming pools has shown that both these disinfectants are effective on a wide range of microorganisms in pool water, often superior to chlorine. This is especially the case for *Cryptosporidium* oocysts which have been well documented to be highly resistant to chlorine-based disinfectants. The major issue noted in the literature for both ozone and UV is their inability to maintain a disinfection residual in the pool water once the water has passed through the filtration and treatment system. As a result, there is a requirement for ozone and UV systems to be combined with a second disinfectant, commonly chlorine, that does maintain a residual in the pool water. Ozone systems are also complicated systems that are expensive to run. In addition, ozone is toxic to pool users and any residuals need to be removed from the water prior to reintroduction back into the pool. There have been reports in the literature that ozone can produce disinfection byproducts. UV has not been implicated in the production of disinfection byproducts, however the need for use of a secondary disinfectant, usually chlorine, means that disinfection byproducts can be detected in swimming pools that employ UV disinfection. In contrast, there have also been reports in the literature that high pressure UV treatment of water can reduce the concentrations of some disinfection byproducts.

The final pool disinfection system investigated is the use of silver:copper ions. Silver and copper ions were reported to be developed for use as pool disinfection systems in the 1920s but were discontinued due to the over availability of much cheaper chlorine-based disinfectants. There has been more recent studies commencing in the 1980s that have reported on the potential use of silver:copper ions as a potential swimming pool disinfectant. Silver:copper ion treatment systems are already used in hospitals for the control of *Legionella* in water distribution systems, catheters and other devises where bacterial biofilms can occur, as *Legionella* is able to exist and hide from disinfectants in biofilms. As silver and copper ions do not interact with organic compounds, they are more effective at removing bacteria such as *Legionella* that can reside within the organic matrixes that form biofilms. The lack of interaction of silver and copper ions with organic compounds means that the silver and copper ions are not impacted by bather loads and other sources of organic compounds introduced into pool water and therefore a disinfection residual is easily maintained in heavily used swimming pools employing silver and copper ions. The lack of interaction with organic compounds also means that there are no recorded instances of disinfection byproducts being produced by silver:copper disinfection systems. In addition, silver and copper ions are not photodegraded by sunlight, impacted by pH, temperature or volatilisation which enables silver and copper ion concentrations to be much more easily maintained in outdoor swimming pools exposed to sunlight and other environmental conditions.

The studies in the literature have shown that silver and copper ions can be as effective as chlorine in the removal of *Pseudomonas aeruginosa* and faecal coliforms. Several of these studies have also tested silver:copper ions under simulated pool conditions through the use of tap or swimming pool water, in place of controlled buffer conditions. These studies have also often added organic compounds to further simulate swimming pool conditions. These studies found that there was no impact on the disinfection capability of silver and copper ions under the conditions tested.

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Studies reported in the scientific literature on the disinfectant capability of silver and copper ions on viruses indicated that silver and copper ions may also be less capable in inactivating the viruses tested than chlorine-based disinfectants. Interestingly though, the use of low chlorine concentrations in conjunction with silver and copper ions was significantly more effective at inactivating these viruses than the use of only either copper:silver ions or higher concentrations of chlorine. This indicates that silver and copper ions still have some disinfection capability on viruses, although slower than chlorine.

There is no reported information in the scientific literature on the influence of silver and copper ions on the (oo)cysts of the protozoan pathogens *Giardia and Cryptosporidium* in swimming pools. Information on the disinfection capability of any disinfectant on *Cryptosporidium* is important as this protozoan pathogen has been implicated in a large number of illnesses from swimming pools, primarily due to its high resistance to chlorine-based disinfectants. There is one paper that was found in the literature that investigated the influence of silver and copper impregnated into ceramic water filtration pots on the viability of *Giardia* and *Cryptosporidium* (oo)cysts. This paper demonstrated that silver and copper was capable of reducing the number of viable (oo)cysts in the water and at a rate that was similar to the reported disinfection rates for chlorine on *Cryptosporidium* oocysts. While the information from this paper suggests that silver and copper ions may be at least as effective as chlorine on the inactivation of *Cryptosporidium* oocysts, this remains a required research area to provide accurate, scientifically based data.

The patented disinfection system by Enviroswim is an advanced treatment system based on the use of silver and copper ions with careful balancing of the silver and copper ions to maintain effective disinfection and good pool water quality along with the addition of ultrasound to aid disinfection and chemical precipitation.

The Enviroswim system has been tested by NATA accredited laboratories in Australia and New Zealand and the National Sanitation Foundation in the United States. Testing by all three entities demonstrated that the Enviroswim ES3 system effectively inactivated *Pseudomonas aeruginosa* better than the required 4 log removal to meet the NSW Health Department guidelines. In addition, the National Sanitation Foundation testing was able to demonstrate that the Enviroswim ES3 system was able to meet their NSF 50 standards.

In addition, long term testing by major swimming pool complexes using the Enviroswim silver:copper ion disinfection system, showed that *P. aeruginosa*, faecal coliforms and *Staphylococcus* could not be detected in the water of any of the pools including heavily used pools and pools dedicated for toddlers. This testing also that the Enviroswim ES3 system could control heterotrophic plate count bacteria with many of the samples producing a NIL detect result for HPC and all but a very few other samples having HPC numbers well below the NSW guideline values of 100 cfu/mL

In conclusion, the review of the scientific literature on disinfection systems for swimming pools has shown that there are several choices that are available for maintaining the quality of swimming pool water. All the disinfectant systems reviewed have both positive and negative characteristics, all of which should be taken into consideration by regulators and swimming pool operators.

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Despite this, my assessment is that the Enviroswim efficacy as a public swimming pool disinfectant meets and exceeds Code of Practice listed minimum chemical criteria by which a swimming pool and spa pool must be operated to minimise public bather risk to acceptable levels.

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