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**Air & Water**

**Fresh Air – Fresh Water**

We have been “circling the wagons” with the “pool atmosphere” concept for quite a few years now. There is literally a dozen or more “expert” opinions on water and air quality and almost all of them have some good points. At the present time over 50% of the Facilities Development Department’s “please solve my problem” type calls have to do with poor air quality. The information listed below is written in lay-persons terminology and may help you investigate and solve your specific problem.

First & Foremost: Air Quality and Water Quality are dependent on each other. Air quality will be affected by:

* **The amount of fresh air that is being introduced into the building every hour.** *This is totally dependent on outdoor climate and type of building. A 90% change of air every 20-25 minutes works well in warm areas.*
* **The condition of the air handling equipment filters.** *The filters should be cleaned or changed every 3 months. There are micro-filters that filter out more air-borne contaminates than the standard fiberglass or paper filters*.
* **The type of air handling system you have.** *Do you have a Desert-Air type system and is it regularly serviced and working properly?*
* **Routine maintenance must be done and tracked on all pieces of air handling equipment.** *Vents and louvers must be checked and lubed at least 4 times a year to make sure they are working properly. Dust must be removed from surface of vents. Motor belts and fuses also need to be checked.*
* **The air flow across the surface of pool and the amount of air being exhausted from the pool room.** *If the sizing of the HVAC system or the duct design was not engineered correctly, there are retrofits and new technologies that can help correct the under-design of the original equipment, These are standalone units with air flow in gutters or benches.*

If the air smells like chlorine – something is wrong. That acrid smell we sometimes associate with chlorine is usually an ammonia type compound. In the swimming pool industry, the “cause of this odor” is called “chloramines”. Chloramines (combined chlorine) occurs when free chlorine combines with ammonia and other nitrogen compounds. This “combining process” can be accelerated by perspiration, urine, saliva, body oils, lotions and some shampoos/soaps, fertilizers, and many industrial or household cleaners. The odor is created when water is not properly balanced. The odor intensifies when swimmers agitate the water – as in kicking or general warm-up swimming. The odor is worse at water level but can be extremely irritating at deck level or in the viewing area. Many times, not only an odor is noticeable, but eye irritation and difficulty breathing is also experienced. Sometimes the water may be hazy – but not always. Many times, the water will appear perfectly clear and the water test for free chlorine and pH reads normal.

This has become such a widespread problem in indoor pools that literally hundreds of people are hospitalized each year. People with Asthma can findthemselves in Intensive Care if exposed to this type of pool condition for even a short period of time. Most of the problems occur in indoor pools. Outdoor pools have plenty of fresh air and sunshine (ultraviolet light) so they are not as susceptible to the chloramines problem.

Chloramine formation can be accelerated by:

1. Swimmers not properly showering before entering pool. See articles and info on PPCP’s (Pharmaceuticals and Personal Care Products)
2. People using the pool rather than getting out and going to the restroom.
3. People doing a high level of aerobic activity and sweating in the water. *(everyone sweats in the water – the same as if they were doing exercise on land)*
4. Residues from ammonia-based cleaning products that are used on decks or in shower rooms/lavatories.
5. Residues from fertilizers used on landscaping (nitrogen based) that get tracked into building on everyone’s shoes.
6. Poor air circulation and lack of fresh air introduction into the pool building.
7. Overuse of “shocking” the pool for maintenance purposes.
8. Improper use of certain brands of chemicals not suitable for conditions specific to a geographic area.
9. City water containing chloramines.

What do we do if this occurs ?

Let’s divide the answer into 2 parts:

1. short term solution
2. prevention

SHORT TERM SOLUTIONS:

If Chloramines are detected the most prevalent solution is to “shock” the water. This means super-chlorination (break-point chlorination) or raising the level of chlorine in the pool to 10 parts per million. Normally a dry chlorine powder or a liquid chlorine is used to achieve super-chlorination. Recent studies show that many times this is not as effective as Hyper-chlorination which is raising the level of chlorine to 20 parts per million.

These methods may temporarily “burn out” chloramines but will also necessitate the pool being closed for a few days. More than the normal amount of fresh air will also have to be introduced during this process. Shocking the pool can create a whole new set of problems and has been found NOT TO BE EFFECTIVE as a solution for chloramines.

Some success has been realized with a non-chlorine shock additive. Adding an Oxidizer (Potassium Peroxy, Monosulphate = brand names Oxykleer or Oxybrite) to the water to convert the available chlorine to free chlorine can release the available chlorine to free chlorine. If this process is done in the evening, swimmers can usually be in the pool the next morning. Fresh air introduction is still important. This is NOT a permanent solution.

PREVENTION:

Usually more than one thing needs to be changed to alleviate the problem.

The most common methods are:

1. Change the air circulation system to include more fresh air introduction and better turnover or more efficient closed system circulation and dehumidification.
2. Evaluate the type and brands of chemicals being used to treat the pool water for both chlorine and pH control
3. Evaluate the pool filtration system to see if a filter that filters down to a more effective micron rating (like DE at 4 microns) would help.
4. Check the labels on all cleaning products to make sure they do not contain ammonia or are not nitrogen enriched.
5. **Have your staff attempt to get the users of the pool to take 30 second rinse type showers before entering – this is usually required by state health codes. THIS IS SUPER IMPORTANT. A 30 second warm shower rinse can help alleviate 2/3 of the problem.**
6. **Consider installing a medium pressure Ultraviolet (UV) water treatment system that cuts down on the amount of chlorine you have to use and also “breaks down” mono and di and tri chloramines.**
7. If the city is using chloramination rather than chlorination install an activated carbon filter on the pool freshwater fill line. This will remove chloramines from the source water before it gets into the pool.

When does the pool water need to be changed?

That depends on:

1. The size of the pool
2. The water temperature the pool is kept at
3. The bather loads
4. The type and brand of chemicals used
5. The type of filter and the turnover rate

In general – the smaller the pool the more frequently the water has to be changed. Hot Tubs in the 300-600-gallon range need to be drained and refilled at least monthly. Many State Dept. of Public Health’s require that exact schedule.

Many specialty pools – such as lessons pools or therapy pools in the 1,500 to 5,000-gallon range need to be drained every 3-4 months. The warmer the water and the higher the bather load the more frequent the water needs to be changed.

Larger pools – such as lap pools and competitive pools can go years before needing to be drained. Because of the large surface area of these pools exposed to evaporation, new water is constantly being added. In effect the water is always in a state of renewal. I have seen pools with perfect water that have not been drained for 4 years or more.

Some things that can shorten the life of the water and necessitate early draining:

1. Improper chemicals with non-soluble buffers or binders and poorly designed “inert ingredients”
2. Poor quality filtration
3. Continually “shocking” pool to break up chloramines
4. Users not taking showers before entering pool

Problems cannot be ignored. Serious health and safety issues are involved. Everyone who works in an aquatic facility needs to be made aware of the importance of a clean and healthy environment.

***It should be everyone’s priority to protect all pool users and staff from “bad air”. In almost all cases, “bad air” is caused by “bad water chemistry”. The athletes need to be your primary concern. If multiple athletes are having trouble breathing, coughing, burning airways, etc. the first step is to immediately contact the pool management team. They have a water test they can do “on-the spot” to test for free chlorine, pH, and combined chlorine (chloramines). If water is out-of-balance, then the pool and pool room need to be cleared until water is balanced and air is clear. This may cause the immediate cancelling of practice or seriously delaying the session of a meet. There are state swimming pool health codes that govern this.***

***If you feel athletes are at a health risk, then it is up to the individual coach or instructor or their immediate superior to take the proper action to protect all pool users. Time is of the essence in these situations and immediate action needs to be taken.***

Things that don’t work well and may waste your time and money:

* Tiring gimmicky chemical that promise they are better than Chlorine. First of all every State Department of Public Health requires there be a minimum Chlorine or Bromine residual of 1.8 to 2.5 ppm. Chlorine free pools are not allowed, nor should they be.
* Salt generated Chlorine pools – Saline – are NOT CHLORINE FREE. They still must have the minimum Chlorine ppm just like any other pool. They simply derive their CL from NACL (salt) and the results are an extremely corrosive environment in the pool, the pool room, and the filter room. Ask us to send you a separate email on this.
* Chemical drips and electrolysis type chambers – they aren’t effective for commercial pools.
* Low pressure UV is less expensive but does not work well in indoor pools. Always go with Medium Pressure UV units in the filter room.
* Extra exhaust fans or ceiling fans. While exhaust fans can help the spectators, the swimmer still have the chloramines being drug across their faces, so they are breathing the worst air possible. Treat the water first then the air. Ceiling fans may make the room more comfortable but if the air is chloramine laden, then all is being done is blowing bad air back down to the spectators and pool users.
* Deck side air treatment liquid filters and treatments. While some of these systems may work for small learn to swim pools or therapy pools, they have not proven effective for regular size pools. Especially during our swim meets when pool experiences a high bather load. The trials we have seen were not successful. Watch out for inaccurate marketing.

While Medium Pressure UV has been proven to destroy chloramines, the water can only get back to the filter room for UV treatment once every 6 hours. Chloramines can form in the pool in 20 minutes. Therefore, the best preventative plan is (in order of importance)

1. All pool users must take showers before entering – this is usually required by state health codes. THIS IS SUPER IMPORTANT. A 30 second warm shower rinse can help alleviate 2/3 of water quality problems. Therefore, all of the newer designed facilities have deck side rinse stations/showers.
2. Educate coaches, pool staff, aquatic directors, instructors, and pool users about the importance of getting out of the pool to use the bathroom. Proper signage at the facility is important.
3. Install a medium pressure Ultraviolet (UV) water treatment system that cuts down on the amount of chlorine you have to use and also “breaks down” mono and di and tri chloramines.
4. If the city is using chloramination rather than chlorination, install an activated carbon filter on the pool freshwater fill line. This will remove chloramines from the source water before it gets into the pool.
5. Evaluate the type and brands of chemicals being used to treat the pool water for both chlorine and pH control. Do not SHOCK the pool unless there is a proven bacterial problem. Shocking can cause chloramines.
6. Evaluate the pool filtration system to see if a system that filters down to a more effective micron rating (like DE at 4 microns) would help.
7. Make sure there are no ammonia based or nitrogen enriched cleaning products that are used on decks or in shower rooms/lavatories.
8. Change the air circulation system to include more fresh air introduction and better turnover or more efficient closed system circulation and dehumidification.

**“UV or not to be” that is the question…….**

Water treatment is almost always the problem when the air is “bad”. Improperly balanced chlorinated pools can cause Asthma, according to research from several sources. These findings may explain why swimmers are more prone to exercise educed Asthma than athletes in other sports. "Results show that nitrogen trichloride (produced by high levels of available Chlorine) is a cause of occupational asthma in swimming pool workers like lifeguards and swim instructors," says Dr. K. Thickett of the Occupational Lung Diseases Unit at the Birmingham Heartlands Hospital. In Dr. Thickett's study, each of the subjects either stopped taking inhaled corticosteroids altogether, or their asthma symptoms resolved significantly once they were placed in other environments away from the swimming pools. Dr. Thickett's study was backed up by research from other European and Australian sources.

The **problem isn't the chlorine**, but what chlorine turns into when combined with organics. The organics are contributed by bathers in the pool in the form of sweat, dander, urine and other organics. The chlorine reacts with the organics and produces nitrogen trichloride, aldehydes, halogenated hydrocarbons, chloroform, trihalomethanes and chloramines. If these sound-like dangerous chemicals, they are. During the Olympic Games held in Australia, it was reported that more than one-quarter of the American swim team suffered from some degree of asthma.

Investigators in Belgium have presented research showing that exposure to such chloramines greatly increases permeability of the lung epithelium, a condition associated with smoking cigarettes. In a study presented by Dr. Simone Carbonnelle, of the industrial toxicology and occupational medicine unit at the Catholic University of Louvain in Brussels, 226 otherwise healthy school children, mean age 10, were followed to determine how much time they spent around swimming pools, and the condition of their lung epithelium. The children in Dr. Carbonnelle's study were exposed to air around the school swimming pool for a mean of 1.8 hours per week.

The level of lung permeability would be the equivalent of what she would expect to see in a heavy smoker, according to Dr. Carbonnelle. "These findings suggest that the increasing exposure to the by products of chlorine-based disinfectants used in swimming pools might be an unsuspected risk factor in the rising incidence of childhood asthma and allergic diseases," she said. The variation in lung surfactants persisted whether the children lived in a rural area or in the city, and whether they were from upper income, or less well-off families, she added.

As part of Dr. Thickett's study, three employees of a local public swimming pool who complained of asthma-like symptoms were subjected to chloramine challenge tests in which, in the lab setting, they were exposed to roughly the same amounts of chloramine as they would be exposed at work (i.e., around the swimming pool, close to the surface of the water). Measurements of nitrogen trichloride were taken at 15 points around the pool, 1 m above the surface of the water. When exposed to equivalent amounts of the chemical in the lab, the three subjects all experienced significant reductions in forced expiratory volume in one second (FEV1), and high measurements on their Occupational Asthma Expert System (OASYS) scores, a measurement of asthma and allergy severity.

In the Belgium study, chloramines in the air around the surface of the pool were measured. In addition, three specific proteins were measured in the children: SF-A and SF-B (surfactant A and B) and Clara cell protein 16 (CC16). Surfactant A and B are lipid-protein structures which enhance the bio-physical activity of lungs lessening surface tension in the lung epithelium and preventing the collapse of the alveoli at the end of expiration. Anything that impairs the function of these surfactants will clearly impair lung function as well, because it makes the epithelium more permeable.

Both studies were concerned with chlorine byproducts in the air above swimming pools. Studies in the United States, Canada and Norway have linked chlorine byproducts in ordinary tap water to higher risks of miscarriages and stillbirths in pregnant women and increased incidences of bladder and colon cancer. Of disturbing news for swimming pool patrons are studies that show much higher levels of these chemicals are found in swimmers. And the highest levels are found in the most active swimmers.

The heightened risk is linked to exposure to a contaminant found in chlorinated water called trihalomethanes (THMs) which forms when chlorine reacts with organic material. THMs are a widely recognized carcinogen. While regulation changes in Canada and the United States have put tighter restrictions on the levels of THMs allowed in tap water, no such regulations exist for swimming pool water.

This is in spite of a study that found a 1-hour swim resulted in a chloroform dose 141 times the dose from a 10 minute shower and 93 times greater than exposure by ingestion of tap water.

Recent Studies on THMs in tap water include:

* A study by California health department investigators Kirsten Waller and Shanna Swann examined the records of 5,144 pregnant women from the Fontana, Santa Clara and Walnut Creek areas. They reported a 15.7% higher chance of miscarriage among women who drank 5 or more glasses of chlorinated water per day.
* A Canadian study reports that women who drink tap water containing high levels of trihalomethanes are twice as likely to have stillbirths. This Dalhousie University study reported that pregnant women increase their risk the more they drink or bathe in water containing the compounds. This study was reported in the scientific journal Epidemiology.
* A Norwegian study of 141,000 births over a three-year period found a fourteen percent increased risk of birth defects in areas with chlorinated water.

Despite these studies on swimming pool patrons, most swimming pool managers are probably unaware that they are exposing their patrons to THMs. This problem is not widely known and for the most part is ignored by the media.

In swimming pools, the most obvious and instant signs of high exposure to these chemicals is red eyes, rashes and other skin irritations or problems. And the highest exposure would appear to be for athletes and other swimmers who exert themselves physically in the water. Researchers report a mean chloroform uptake of 25.8 [micro]g/h for a swimmer at rest and 176.8 [micro]g/h) after 1-hour swimming.

Other studies note that inhalation is an important route of exposure and the uptake through this route is affected by various factors including the number of swimmers, turbulence, and breathing rate. Which means that for elite athletes, the risk of exposure at water level is significantly higher than for that of a casual swimmer. And in both cases, the dosages of THMs far exceed what is considered allowable by merely drinking a glass of chlorinated tap water.

While the incidence of miscarriages and stillbirths is cause for concern, other problems have been identified. Bladder cancer has been linked to chlorinated drinking water in an average of ten out of eleven studies. One of the studies in Ontario, conducted with funding from Health Canada, found that fourteen to sixteen percent of bladder cancers in Ontario showed a direct correlation to drinking water containing high levels of chlorine by-products. Chlorinated water has been linked to colon and rectal cancers in the studies, but the occurrences were not as common as those for bladder cancer.

**Solutions?**

Dr. John Marshall, of the Pure Water Association, an American consumer group campaigning for safer drinking water, states: "It shows we should be paying more attention to the chemicals we put in our water and we should be looking for other alternatives to high levels of chlorination.” There are options that are safe, and non-toxic, such as treating water with ultraviolet light.

With Ultraviolet systems there is a higher initial capital cost to the swimming pool compared to just chlorine feeders. However, over the life of the pool Ultraviolet technologies reduce the on-going operating and maintenance costs. These costs can be significant. Chlorine is famous for destroying pool infrastructures, rusting out ventilation systems and destroying pool liners and coatings etc. UV poses no such problems. The UV pool will be much cleaner, which means dirt, grease, oils, organics and other materials will wind up in the filter system much faster than with highly chlorinated systems. If the filter and strainer maintenance is not stepped up accordingly, the pool recirculating system will slow down and the pool will actually look dirtier than with Chlorine. However, proper maintenance of the filter system will solve this problem.

Part of the problem in adopting UV is that many engineers, architects, pool builders and designers are not all that familiar with the technology. Since our engineering, architectural and other technical training have all been geared to Chlorine, it takes re-education to now apply UV. Many people in these industries are reluctant to "shift gears" and take the time to educate themselves about the proper application of UV.

Chlorine is a complex man-made chemical that found original use in the infamous "mustard gas" of the First World War. Chlorine is also an entrenched technology. It has been widely used in North America and was first adopted at the turn of the century. It is still the reigning champion of disinfection and has many supporters in the chemical and swimming pool industries.

It is the organics that cause problems when combined with chlorine. By reducing the organic load, the Europeans keep the chloramines (the cancer-causing substances) at a very low level. In European swimming pool systems, the same thought process prevails. In German DIN standards, for example, the strategy is to use a large "surge pool" that the public doesn't even see to apply Ozone or disinfection chemicals. The disinfection byproducts are then removed by various filtration processes prior to the water being returned to the pool with a slight dose of chlorine. Under these standards, swimming pool water is essentially treated to drinking water standards.

The North American model developed under much different circumstances than the European. In North America, chemicals were adopted wholeheartedly around the turn of the century as the answer to the larger, more expensive European models of water treatment. Engineers here found they could build water treatment plants and swimming pools at greatly reduced capital costs if they used what was then considered miraculous chemicals to treat water. And, for the most part, the systems did what they were designed to do and that was to kill micro-organisms that could lead to sickness and death. What they didn't anticipate was that chemicals like chlorine would have very serious byproducts that become health hazards themselves.

However, in North America we are now stuck with swimming pools that in Europe would be considered "surge tanks". The challenge is to evolve UV technology that can retrofit a large installed base of swimming pools in an economical manner. These systems are now starting to appear in the marketplace in increasing numbers and the success rate of positive results is amazing.

Once pool owners add UV, they realize that they no longer have to put up with red eye, rashes, unbreathable air and the health consequences of over chlorinated pools.

As the technology becomes more prevalent, expect to see more expertise at the local pool builder or pool maintenance companies. However, many of these companies rely on repeat sales of chemicals. These companies are likely to be highly resistant to UV systems as after-sales revenues will drop. However, for pool maintenance companies that are being paid to keep pools clean, UV is great. They should spend less time maintaining pools and the pools will be cleaner and the water more appealing. In the future, expect UV prices to drop slightly as more consumers become educated, demand for systems will definitely increase.

UV does not replace chlorine but allows you to run a lesser residual chlorine reading and allows the chlorine to be used 100% for disinfesting rather than go into combination with other elements.  Your State department of Public Health will have a copy of your states regulations and limitations for using UV in commercial pool applications. Each state may have different codes and getting them to lower their required minimum chlorine levels can be very challenging.

What is ultraviolet or UV ?  
Ultraviolet light is part of the light spectrum, which is classified into three wavelength ranges:  
  
- UV-C, from 100 nanometers (nm) to 280 nm  
- UV-B, from 280 nm to 315 nm  
- UV-A, from 315 nm to 400 nm.

UV-C light is germicidal - i.e., it deactivates the DNA of bacteria, viruses and other pathogens and thus destroys their ability to multiply and cause disease.

It also breaks down chloramines that develop in indoor swimming pool water.

Specifically, UV-C light causes damage to the nucleic acid of microorganisms by forming covalent bonds between certain adjacent bases in the DNA. The formation of such bonds prevents the DNA from being unzipped for replication, and the organism is unable to reproduce. In fact, when the organism tries to replicate, it dies.

Ultraviolet technology is a non-chemical approach to assist disinfection. In this method of disinfection, nothing is added to the pool water except chlorine and pH control chemicals.

This makes this process simple, inexpensive and requires very low maintenance.

Ultraviolet purifiers utilize germicidal lamps that are designed and calculated to produce a certain dosage of ultraviolet (usually at least 16,000 microwatt seconds per square centimeter but many units have a much higher dosage.) The principle of design is based on a product of time and intensity - they must have a certain amount of both for a successful design.

WATER APPLICATIONS  
- under sink installs & water vending machines  
- aircraft, boats & recreational vehicles  
- water wells & water cisterns  
- **swimming pool & hot tubs**  
- farms, ranches & trailer parks  
- schools & hotels  
- aquarium, hatcheries and nurseries

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**How do ultraviolet purifiers work -** Short wave pressure mercury vapor tubes that produce ultraviolet wavelengths are installed in a watertight chamber. The UV system is installed after the pool filter and the return water to the pool is circulated 100% through the tube. Approximately 95% of the ultraviolet energy emitted is at the mercury resonance line of 254 nanometers. This wavelength is in the region of maximum germicidal effectiveness and is highly lethal to virus, bacteria and mold spores. Therefore, the water or air that passes through the chamber is exposed to the germicidal UV light and the genetic material of the micro-organism is deactivated, which prevents them from reproducing.

The CDC and others are currently conducting test for the effectiveness of UV in killing “germs” and breaking down chloramines. There are still discussions whether low pressure UV is as effective and efficient as medium pressure. Bottom line is that the initial UV test results are good and many pools that have installed UV have seen a 100% turn around in their air and water quality almost immediately. The Facilities Department of USA Swimming strongly recommends that all indoor pools have UV installed.

USA Swimming has identified some of the best providers for UV systems. You can contact us an we will refer you directly to these manufacturers and distributors for pricing.

We have also developed a 20-minute CD power point with audio called the **Safe-WAY**

(**W**ater **A**ir & **Y**ou). E-mail [mneson@usaswimming.org](mailto:mneson@usaswimming.org) for information.