

Introduction

Free available chlorine (FAC) and combined chlorine (CC) measurements are made to determine the amount of chlorine available to interact with bacteria, algae, parasites, and other molecules in treated water; and the amount that is presently bound up and not available for oxidation. In commercial applications, law mandates minimum and maximum levels. Acceptable CC levels are usually required to be below a certain maximum. The mechanical, chemical and biologic factors that interact to determine the measured levels of both FAC and CC are complex, and interrelated.

From the users perspective, all those reactions don't necessarily need to be completely understood, but the major factors affecting FAC and CC are not complex and do need to be understood to keep treated water as safe as possible and satisfy local regulations, so inspectors don't shut down the facility.

FAC and CC Measurements

FAC measurements are made in many different ways. All of them measure of amount of chlorine available to oxidise. Combined chlorine measures everything else that has a chlorine atom as part of the molecule. Chemically, free chlorine is measured directly and then total chlorine is measured by stripping off the chlorine atoms in the sample. By subtracting the FAC from the total chlorine you get the CC level. Therefore, the CC is a huge collection of very different molecules because it measures anything that has a chlorine atom as part of the molecule. A recent study from the CDC used sophisticated chemical analysis to measure 30 of the most common molecules in combined chlorine. They range from all the chloramines, all the trihalomethanes, to very complex molecules resulting from chlorine's interaction with organic molecules.

The molecules that are measured in CC contain most of the molecules that cause discomfort, asthma, vomiting, headaches, itching, hair color change, corrosion in the area surrounding the pool and swimming suit destruction. Other molecules that are part of CC are either harmless or much less harmful at the concentration present in pool and spa water. Unfortunately, measuring the specific molecules in the air and water of a pool or spa is very expensive and takes a special laboratory and a lot of time.

Disinfection By Products

Add chlorine or bromine to most water and you will produce disinfection by products (DBP). Chlorine and bromine oxidise and combine with many molecules in the water creating soluble and volatile molecules. Two well known reactions include: the combination of chlorine and bromine with nitrogen containing molecules to form chloramines and the reaction of bromine and chlorine with carbon atoms to form trihalomethanes.

What effects do DBP's have on people in and around the water? We know a lot about the effect of one DBP – chloroform - since it was the most commonly used anesthetic for decades. The fancy name for this class of DBP is trihalomethane (THM). There are many different THM's with different effects on people just like there are many different types of DBP's that have different effects on people. We will look at chloroform and trichloronitrate (TCN).

Chloroform inhaled at a concentration of 10,000 ppm put you to sleep. Prolonged exposure at this very high level will kill your liver, depressed your heart function and kill you. In human volunteers, exposure to 4,100 ppm causes serious disorientation and 1,000 ppm causes dizziness, nausea, fatigue, and headaches. Prolonged exposure to as little as 10 to 200 ppm can cause liver enlargement and has effects on the central nervous system. For a reference, we measured THM concentrations in two commercial indoor pools in the 1.6 - 1.8 ppm range and have measured THM levels as high as three or four ppm range.

Application of chloroform causes redness of the eyes and itching of the skin. One study of people exposed to low levels of chloroform in their drinking water showed a correlation between chloroform concentration and rectal and bladder cancer. In fact, an international health agency classifies chloroform as a carcinogen for humans.

Other studies, especially from Europe, have documented the effect of trichloronitrate (TCN) on swimmers. They conclude that this DBP is related to reactive airway disease or asthma in people who swim frequently. Another study shows that DBP's are associated with changes in DNA in urinary bladder cells that correlate with an increased risk of cancer.

To summarise, DBP's not only smell bad, they irritate your skin, eyes, and lungs; cause central nervous system changes such as dizziness and headaches; cause fatigue; and with prolonged exposure are potential carcinogens.

The most prevalent nitrogen-containing molecule in the swimming environment is urea from urine and sweat. Urea undergoes chemical changes in the pool and combines with chlorine or bromine to form over 30 different DBP's. Some of these molecules stay in the water and others are volatile so they diffuse into the air above the water and eventually into the entire building. The act of swimming actually increases the concentration of DBP's by turning up the water and increasing the concentration of these molecules in the air.

Recreational Water Ecosystem, FAC and CC

The water in a pool or spa comes from a water source, usually a municipal water system or a well. The characteristics of that water vary greatly in different parts of the country. Some areas have high calcium and iron levels, others have a high bicarbonate levels and some have unique inorganic and organic contaminants. The characteristics of the water source can also change from hour to hour. Some communities draw water from a number of different wells and each has its own unique profile. Depending on the time of day or day of the week, the incoming water can be very different. In addition, chlorine and monochloramine are added to municipal water supplies to disinfect the water as it flows from the source, through the pumps and water towers, to the pipes that eventually deliver the water to the facility. The rate that these chemicals are added to the source water also fluctuates depending on many different factors.

For example, some communities disinfect source water with monochloramine. Monochloramine registers as a CC. Source water can contain up to 4 ppm monochloramine, but pools usually can't have over 0.5 ppm of total CC. THM's are also present in source water at fairly high concentration.

So, depending on the source water some pool managers are fighting a very up hill battle to maintain their CC levels below legal maximums while others have an easier time. That's only the start of the problem. Once water is delivered to the pool or spa, local factors in the pool, on it's surface, it's filters and on it's pipes can produce more CC molecules and increase the concentration of chloramines and THM's. People in the water also are a major source of nitrogen containing molecules from sweat and urine, adding to the CC level when the nitrogen containing molecules combine with FAC.

One of the major contributors to CC formation is the collection of organic contamination in the pool filter, pool surface and on the pipes that course through a pool complex. Organic contamination also occurs in spas on every surface. Organic contamination creates a unique microenvironment in the pool that facilitates the formation of DBP's and the bacteria that live within the organic contamination release nitrogen containing molecules into the water. Chlorine effectively kills swimming bacteria and when the bacteria die, they release all of their nitrogen containing molecules into the water that then combine with FAC to create even more CC.

The Effect of PoolMoss® Pro and SpaMoss® Pro on CC and DBP's

PoolMoss® Pro and SpaMoss® Pro systems treat recreational water with Sphagnum moss that naturally conditions the water and reduces the organic contamination.

When we started treating indoor commercial pool water with PoolMoss® Pro, we found that the air quality in the pool area improved in a couple of days and the air in the entire facility was significantly improved after a week of treatment. In outdoor pools treated with PoolMoss® Pro, swimmers and pool users reported less irritation and asthma. Over time our customers started saying that the only way you know there is a pool in the building is to see the water. Swimmers, coaches, lifeguards, and pool patrons all reported less eye, skin, hair, and lung irritation. After a swim meet in one of our pools, many swimming teams demanded that their facilities add the PoolNaturally® Plus system.

To measure the effect of PoolMoss® Pro on DBP concentration, we did a study with a fitness club to measure the THM in the air above the pool surface and the water in their two indoor pools. We measured levels weekly for two weeks before PoolNaturally® Plus was introduced and then every week for 24 weeks. They have a high bather load and use liquid chlorine for a disinfectant. We measured a steep decline in THM in the water resulting in a 75% reduction at 24 weeks. In the air above the pool, the THM concentration was decreased by 55%. The air quality improved just like at our other indoor facilities.

How Does PoolNaturally® Plus affect DBP Production?

We know that treatment of a pool with PoolMoss® Pro decreases organic contamination, THM levels in the pool water and in the air above the pool water and in the facility. We also know that the smell changes within one to two weeks after starting PoolMoss® Pro treatment. In addition, we know that the effects of DBP's such as eye and skin irritation, asthma, nausea and vomiting, and headaches also decrease significantly when water is treated with PoolMoss® Pro.

CC levels may or may not decrease with PoolMoss® Pro treatment depending on:

- The amount of organic contamination in the filter
- The effectiveness of the filtration media
- The bather load
- The temperature of the water
- The level of CC in the source water
- The frequency of back washing

Air Scour with Breakaway® flush

CWS developed a simple and remarkably effective method to remove 85 to 90% of organic contamination from sand or glass filter media with 45 minutes of treatment – thus providing a way to decrease the formation of CC in the pool or spa system. We found that differential pressures decreased across the media bed, flow increased, the frequency of backwashing decreased, and CC levels decreased. One of our customers, with hundreds of pools nationwide, Air Scours every filter twice a year with Breakaway® flush to remove organic contamination and keep CC levels low.

Selection of Filter Media and Organic Contamination

The customer mentioned above also asked us to determine the amount of organic contamination that is contained in five different filter media so they could choose which one brought the least contamination when the media was changed. They also wanted to know which media released organic contamination with standard backwash and with the Breakaway[®] flush Air Scour procedure. We tested two glass media, two sand media and a synthetic porous media. We found that the two glass media contained the least organic contamination out of the bag. The more expensive sand had more organic contamination than the glass and less than the less expensive sand. The synthetic porous media had, by far, the most organic contamination.

When we grew organic contamination on the media and determined the amount of it remaining after Breakaway[®] flush treatment, the results were similar: glass media performed best (had the least organic contamination remaining); synthetic porous media was the worst (held onto organic contamination); and sand was in the middle. The company chose to replace all their media with glass and has two years of experience with Breakaway[®] flush treatment with excellent results.

The Effect of PoolMoss[®] Pro and SpaMoss[®] Pro on Filtration and Backwashing

We have over 400 commercial bodies of water treated with PoolMoss[®] Pro. When filters are backwashed using differential pressure, frequency of backwashing decreases dramatically overtime. We believe that this is due to the removal and inhibition of organic contamination accumulation in the media of all filters (paper, glass, sand, and regenerative filters). Decreasing backwashing results in less make up water being used - and if the make up water has a high concentration of CC (like monochloramine), the pool's CC level will increase the more backwashing occurs. The most effective combination to keep CC at a minimum is combining routine Air Scour and Breakaway[®] filter treatment with PoolMoss[®] Pro treatment of the pool water. Back washing by differential pressure is essential to realise maximum decrease in CC.

Reducing CC in Make Up Water

Presently the most effective (and the most expensive) way to assure that make up water has no CC is to install a Reverse Osmosis system on the water supply line. We are presently working on a much simpler, easier and cheaper solution to remove both CC and excessive levels of iron, manganese, and phosphate. We are beginning beta testing, and if it performs well, we will add this to our line of solutions for residential and commercial pools and spas.

For technical support please contact [Clear Water Supplies International Limited](#) or visit www.CWSNaturally.co.uk

