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Information

Algae and Algaecides

Algae
Algae are microscopic single celled forms of plant life that are introduced into the water by wind and rain from the atmosphere. There are 30,000 different varieties of algae all containing chlorophyll. They are one of the hardiest and most widespread living organisms on this planet.

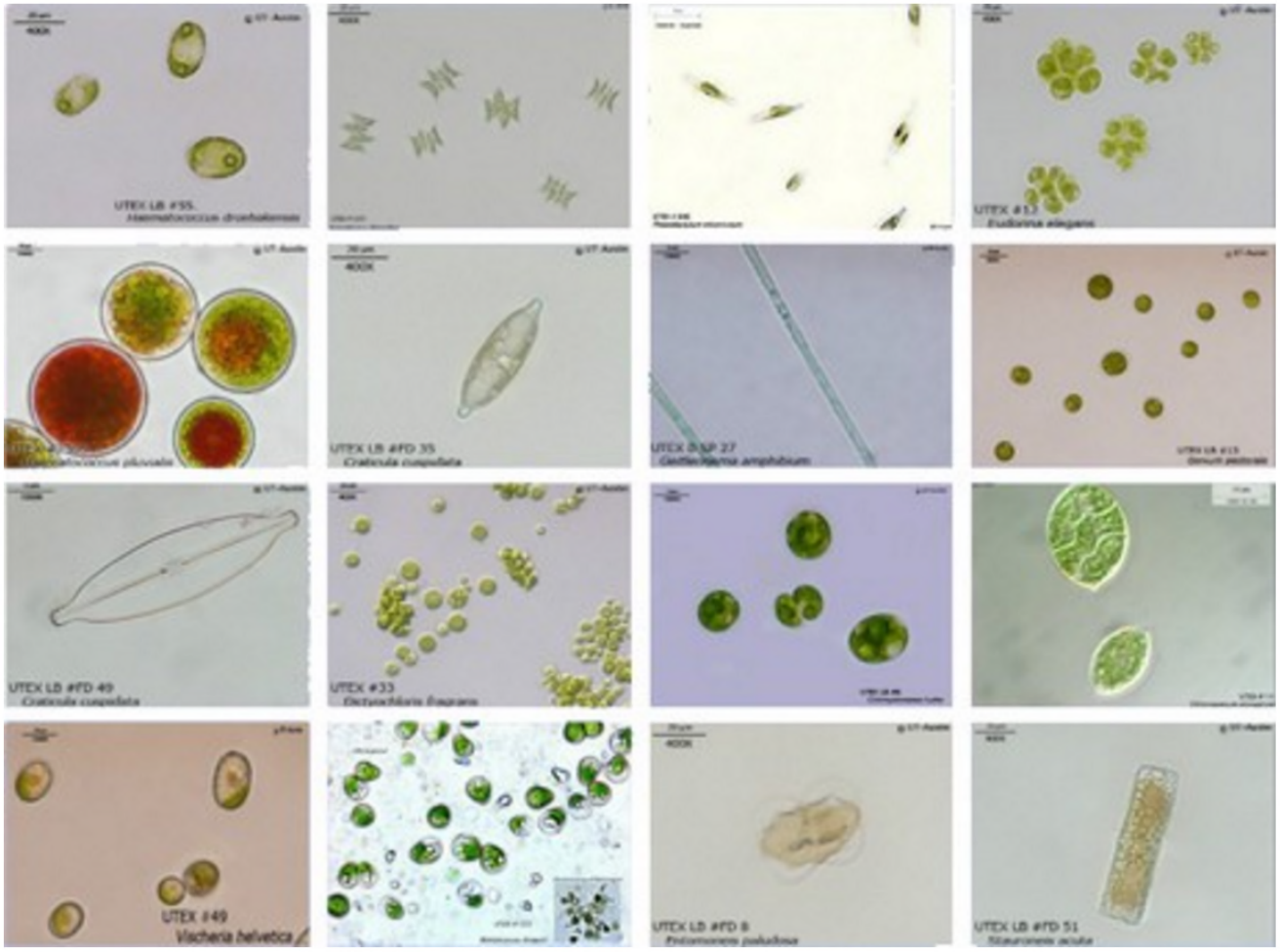
There are three main categories:

1. Green algae
Usually floating algae, although they sometimes cling to walls. This is also the fastest growing algae and accounts for most 24hr algae blooms. Pool water becomes turbid with a green growth that renders the pool uninviting and dangerous to use as it is difficult to see the bottom of the pool. Prior to the green coloration appearing, the sides of the pool have a slippery feel and the water becomes hazy and exhibits a high chlorine demand.

2. Mustard (yellow) algae
Appear as a yellow powdery deposit on the pool, usually on the shady side. Once established, they are chlorine resistant and can exist in the presence of 3-5 ppm free chlorine. These are also a common algae which grow in aquariums in areas that get little light.

3. Black (blue-green) algae
Evident by the formation of 1 to 3cm sized black (or dark blue green) spots which tenaciously adhere to pool surfaces. Black algae form a layered structure where the first layer (which chlorine may kill) protects under layers from further destruction. Black algae are similar to the black algae found on bathroom shower tiles and in silicone seams near the bath. They are also found in aquariums as dark blotching on the glass sides. These algae are very slow growing but very hardy and extremely chlorine resistant.

An algal bloom can turn clear clean water into a green swamp overnight. The pH can climb (as algae consume carbon dioxide which helps keep pH down) and the pool walls become slippery and hazardous underfoot. Once algae are visible then a substantial problem exists. Algae take in carbon dioxide and gives off oxygen like most other plants. Most bacteria found in swimming pools take in oxygen and give off carbon dioxide. Each consumes the by-products of the other for growth. It is desirable to use a chemical program that assures both bacterial and algae control.



Prevention of algae

A proper chemical programme of regular pool maintenance prevents algae from growing. This means keeping the proper pH and recommended free chlorine residual for your pool. The best algaecide (algae killer) and algaestat (algae inhibitor) is a properly maintained sanitiser level of 1-3ppm chlorine or 2-5ppm bromine for a pool and 3-5ppm chlorine or 3-6ppm bromine in a spa. Algae are very rare in most spas and hot tubs as the insulating hard cover does not allow enough light for the algae to get a foothold. Algaecides are chemicals added to the pool water to control algae. While algaecides can kill algae at high dosages, most are utilised as algaestats, which prevent algae formation when chlorine is allowed to become depleted.

The following algaecides must not be used when the pool is fitted with an ORP controller. Ions in the algaecide can electrically plate onto the ORP electrode's platinum surface, reducing its readings. In any case, a correctly controlled pool should not develop an algae problem.

There are three main groups of algaecides:

1. Quats

The largest selling, lowest priced algaecides. These are most often found in active concentrations of 5-10%. Such quaternary ammonium salts are surfactants and if added in excess, will cause foaming on the pool surface. Surfactants lower the surface tension of the water and ‘wet’ algae cell walls. This wetting splits open the cell wall and kills the algae. Quats require lower concentrations and amounts than polyquats to achieve the same level of prevention. Quats are most often used as the preventative while polyquats are most often used to get rid of existing algae.

2. Polyquats

These are non foaming algaecides sold in concentrations of 30 to 60%. While more costly than quats, polyquat algaecides are very effective not only on green algae but also with the chlorine resistant mustard and black algae and work well at destroying visible algae.

3. Copper salts

Copper ion (Cu++) is a very effective algaecide used in ponds, lagoons and pools to kill and prevent algae formation. Copper usage can cause stain formation. Over time, soluble copper salts can precipitate from pool water and deposit on pool walls, creating a blueing effect. In the presence of chlorine, these salts will turn to cupric oxide and cause grey to black staining of the pool walls.

4. Colloidal silver

Silver is similar to copper in may ways, colloidal silver attaches itself to the pool walls and floor, giving these surfaces a residual and continuing algaecidal action. Silver can also cause a black staining to occur on pool walls if not carefully administered. Silver is also a very good bacteriostat that may reduce the need for chlorine. Some ionisers use copper and silver plates to produce both silver and copper ions in the water.

To Treat Algae

Step 1

To treat algae once they take control of a pool, check pH and adjust if necessary. Check filtration, filter pressure and backwash if necessary.

Step 2

For green algae, you can use one of two methods or implement both.

Super-chlorinate the water with up to 30ppm chlorine. If necessary, 24-48 hours later when the chlorine drops to normal levels, add a good all-purpose algaecide according to package direction.

The next day, vacuum the dead algae and backwash the filter if necessary. Use of a good 'floc' can help speed up the settling of dead algae. In the case of heavy algae growth it may be necessary to repeat the treatment. After algae have been vacuumed, check pH, adjust if necessary, and institute a program of super-chlorination and use of a good all-purpose algaecide. Make sure the chlorine level is maintained at proper level to help prevent reoccurrence.

For black or mustard algae: brush the algae spots vigorously with a stiff brush. Shut off the pump, and use chlorine tablets to spot treat the algae spots carefully (not recommended for vinyl lined pools). Then pour a good concentrated all purpose algaecide on the algae spots. Leave dissolved algaecide in contact with the algae overnight. Restore water circulation then brush dead algae and vacuum to waste. In case of heavy algae growth it may be necessary to repeat treatment. After algae have been vacuumed, check pH, adjust if necessary and institute a programme of super-chlorination and then use a good all-purpose algaecide. Make sure chlorine level is maintained at proper level to help prevent reoccurrence.

Ozone Gas will Sanitise and Oxidise

Ozone is a gas, a modified highly reactive form of oxygen (chemical formula: O_3). It is one of the strongest oxidisers and disinfectants available. It is stronger than chlorine, bromine, hydrogen peroxide and hypochlorous acid. Ozone kills *E. coli* (commonly used to measure the effectiveness of sanitisers) 25 times more powerfully than hypochlorous acid (chlorine) and about 500 times faster.

There are two main methods of producing ozone. In the Corona Discharge Method, air is passed through an electrically charged chamber, where a miniature lightning storm produces ozone from

oxygen. In the UV Method, air is passed close to one or more ultraviolet lamps where UV rays excite oxygen which then forms ozone.

An ozone generator in combination with chlorine or bromine reduces the chlorine or bromine used (up to 95% less). Chlorine or bromine is still required to kill the bacteria and must still be measured and tested for. Ozone can only oxidise organic wastes once chlorine or bromine has combined with them. Ozone only lasts between 20 seconds and 6 minutes in most spas and pools. Ozone will oxidise some minerals dissolved in the pool water like iron which then forms a cloudy precipitate which the filter will remove.

Once the ozone has done its job it reverts back to oxygen which makes the water look, feel and even taste better.

Copper and Silver Ion Generator Sanitisers

The information in this section is based on the gathering of information from sources that advocate the use of copper and silver ion generators for pool sanitising. It is strongly advised that anyone considering the use of this technology should consult a suitably qualified, independent authority before going ahead.

Ionisers

Ionisers use a process of electrolysis (passing electric current through water) to create metallic ions in water. If the cathode is copper then copper ions (Cu^{2+}) are created. Copper ions in water inhibit algae growth. Adding copper sulphate or a copper based algaecide makes copper ions when dissolved. Silver ions in water kill bacteria.

Ionisers work by passing a low DC current through a set of metallic electrodes, placed in line with the circulation system and set slightly apart from each other. The voltage causes some of the outermost atoms of the electrodes to lose electrons, which attempt to flow across the space between the electrodes but instead are carried away by the flow of water. Some systems use a copper and a silver electrode; other systems use two copper electrodes, which produce copper ions only. Still others use a pair of bi-metallic electrodes which produce both copper and silver ions.

Do you really need both copper and silver and at what level are they effective? How do you control organic contaminants? How do you avoid staining? What else is needed? Let's look at a copper/silver system and an all copper system one at a time.

Copper / Silver Ioniser Systems

Copper/silver systems require the use of a copper test kit to indicate ion test levels in the water. As both copper and silver ions are being dispersed at the same time it is only necessary to check for the presence of one to know the other. The rate of ion creation is proportional to the ratio of copper and silver in the electrode. A copper test is performed much as you would test for chlorine residue. A level of copper in the range of 0.15 through to 0.20ppm, a pH of 7.2 through 7.4 and a total buffering of 80-100ppm is recommended.

The ion level is adjusted by changing the current flow across the electrodes using a manual dial on the control unit. pH and total alkalinity are adjusted by traditional methods. Potassium peroxyonosulphate can be used to get rid of organic contaminants and removes the slimy protective bio shield that forms over algae. Chlorine can also be used for this purpose. The dosage rate is 1kg per 70,000 litres for a permonosulfate compound (non-chlorine shock). Liquid chlorine can be used at the rate of 600ml per 35,000 litres added in the evening so it has gone by morning. Cyanuric acid contained in stabilized chlorine compounds may be precipitated by silver ions. If copper stains develop a chelating agent is recommended or can be used as a preventative.

All Copper Systems

A copper test kit is used to monitor ion levels in all copper systems. Copper alone can control both bacteria and algae thus eliminating problems of silver ions reacting with sunlight to form a black precipitate on pool walls and equipment. As this system relies on copper only for bacteria and algae control, a higher copper level is recommended. Use slightly less than 0.30ppm in the off-season and 0.30-0.50ppm during periods of heavy use, maintaining a pH of 7.2 through 7.4 and total buffering of 80-120ppm. Except when the system is first installed no oxidiser is recommended. After the system is operating the only regular chemical treatment is a non-polymer flocculating agent added once a month at a rate of 240 ml per 35,000 litres (480 ml if water clouds). A chelating agent is used to reduce the level of metals in the water and prevent staining. Oxidation of organics is accomplished in the ion chamber where in addition to producing ions the electrodes also electrolyse some water separating it into two elements hydrogen and oxygen. Whether the amount of oxygen produced in the chamber is sufficient to take care of all organic waste is open to some question. It is therefore recommended that a chlorine residue be maintained at 1-2ppm with regular shock treatments with chlorine or a non-chlorine shock. As for algae's bio-shield, we recommend brushing to remove it then the ioniser will take over.

Ioniser Maintenance

The residual provided by an ioniser comes from a gradual erosion of the electrodes. This is true for copper/silver, bi-metallic and all copper systems. Depending on the type, electrode life is estimated at one to two years. You should remove any scale that has formed prior to the installation of an ioniser. Properly maintained and sensibly applied an ioniser system is capable of satisfying basic sanitation needs. By itself, an ioniser is able to deal with algae and bacteria but problems with water balance, disposal of organics and proper filtration are not things that an ioniser can handle by itself.

Ultraviolet Ray Sanitizers

UV Sterilising

Bacteria or pathogens exposed to high intensity ultraviolet rays in the germicidal wave length frequency range of 253.7 nanometers are killed. This level of energy of radiation disrupts the DNA bonding and stops the bacteria from breeding and consequently the organisms die (bacteria that can't reproduce are considered dead). UV radiation is extremely effective in killing micro-organisms such as viruses, bacteria and mould spores without altering or affecting the water. Some bacteria or viruses that cling to the pool or spa walls, pipes or filters may not go through the UV chamber. Water must still be sanitised, disinfected and oxidised 1-3 times per week with 4-5ppm of unstabilised granular or liquid chlorine (depending on the load). This eliminates any bacteria or viruses that have not passed through the UV chamber. The UV light rapidly breaks down chlorine and in 4 to 8 hours the spa or pool water is free of chlorine. The best quality of water to soak and relax in. Once you know how much you need for your application you don't need to test your chlorine again other than to periodically confirm that you have used enough chlorine.

Do not attempt to use a floating dispenser in conjunction with a UV chamber as the chlorine or bromine will never reach a high enough residual level to be effective in killing bacteria on the walls and in the plumbing.

The UV chamber will just burn off these chemicals as fast as they dissolve and before you know it your Total Dissolved Solids will build up to an unrecommended range causing other problems. All systems chemical free or not, require proper pH levels and clean filters. This system is a bacteria steriliser and not a primary disinfectant. This product is perfect for residential pools and spas.

Chlorine Generators
Producing chlorine by electrolysis.

When direct current is passed through water containing NaCl (common salt):

- Negative chloride ions (Cl^-) lose an electron to the positive electrode. They pair up and bubble off as chlorine gas (Cl_2).
- Positive hydrogen ions (H^+) get an electron from the negative electrode. They pair up and bubble off as hydrogen gas (H_2).
- Left behind in the water are sodium ions (Na^+) and hydroxide ion (OH^-).

Salt Chlorinators

This generator produces chlorine directly in to the pool or spa from a low concentration of salt added to the pool water. (The pool has salt added to it). Electrolysis takes place in an electrolytic cell installed 'in-line' in the recirculation system. Inside the cell are layers of plates that are electrically charged by a separate power supply. Depending on the generator you need to maintain a salt concentration of about 2500-6000ppm in the pool or spa for the unit to operate effectively. This means adding 100-250 kg of salt per 40,000 litres of water.

As the salt water passes through the cell it is super chlorinated preventing the build up of chloramines and because the caustic soda is produced at the same time and is not removed or separated, it neutralises the acidic condition produced from the chlorine gases. This means the pH of the water is not affected. To prevent scale build up on the plates the control unit may periodically reverse the charge on the plates to repel any build up that the opposite charge attracted.

Once the chlorine generated from the water does its job, it reverts back to salt and water to be used over and over again. So it is only necessary to add more salt to replace loss due to bather drag off, splash out, over flow and filter backwash.

Chlorine generators can be automated, although hydrogen gas bubbling of the electrodes interferes with the ORP sensing electrode.

Things that manufacturers of Salt Water Chlorinators generally don't advertise...

- The hidden cost of running the electrodes at several hundred watts continuously whenever the pool pump is on.
- The cost of replacing the electrodes periodically.
- Salt chlorinators are almost never sold with an ORP control system. This means that they will not generate extra chlorine on hot days or when there is a high bather load, resulting in potentially unhealthy water. On cool days with no bather load, they are wasteful as they still generate the same amount of chlorine.
- The salt in the water can cause corrosion of metal pool fittings, and can weaken the mortar joints of coping pavers around the rim of the pool.
- If the pool has a tiled finish around the top edge, the salt tends to form heavy scale build-up that looks awful and is difficult to remove.

Total dissolved solids (TDS) in water create a corrosive situation even when the pH is in its ideal range. Pools should be partially or completely drained when the TDS level reaches 1500ppm above the salt water level recommended by the chlorine generator manufacturer. The pH has to be properly maintained as suggested by the manufacturer.

Brine System Generators

This system uses a two chamber holding tank containing (NaCl) in solution. The chambers are separated by a porous diaphragm or membrane. The positive electrode is in one chamber and the negative in the other. The diaphragm allows electricity and sodium ions to pass through but doesn't allow the chloride ions or water to pass. The chemicals produced at each electrode can not come into contact with each other. The chlorine gas that bubbles from the positive electrode chamber is drawn off and introduced to the pool or spa water. Once in the water the chlorine produces hypochlorous acid (HOCl) and hydrochloric acid (HCl). The hydrogen gas is often vented off into the air and is very explosive. A small portion of the caustic soda from the cathode chamber can be added to the pool to neutralize the acidic effects of the chlorine gas. In all Brine Systems, the anode chamber must be periodically refilled with water and salt, and the cathode chamber must be periodically drained of caustic soda and refilled with fresh water. Some systems require distilled water to be used. Some systems use a sophisticated electronic indicator system that advises the user that maintenance is required while others rely on mechanical alarms.

During the summer season the cathode chamber needs to be drained off about every 4-6 weeks. Some models require that you drain the chamber to a jug. Others allow you to hook up a hose flushing system for disposal.

The caustic soda solution can be used for pH adjustments in the pool or spa or for other household uses such as cleaning drains or it can simply be disposed of. A typical brine chlorine generator designed for a 100,000 litre pool uses 25 kg of salt in the anode chamber. This must be replenished 2-4 times per year. Estimated salt consumption is about 40-100 kg per year.

Chlorine will Sanitise and Oxidise

Oxidizers

There are a number of types of chlorine, bromine and permonosulfate compounds. Each has advantages and disadvantages: cost rating and hidden costs, safety and tips for use as a pool or spa water disinfectant and or oxidiser.

Chlorine Compounds

Chlorine products are required by law to display on the label, their chemical name and concentration. When chlorine in its various forms is added to the water it produces hypochlorous acid (HOCl). Hypochlorous acid both controls bacteria and algae and oxidizes organics. Hypochlorous acid is a weak acid and therefore not harmful to people.

Hypochlorous acid in pools and spas

HOCl dissociates (breaks up) HOCl <===> H^+ + OCl^- (hypochlorite ion).

HOCl reacts with bacteria and organics. HOCl is a very effective sanitiser.

OCl^- reacts with ammonia (NH_3). OCl^- is an extremely strong oxidiser.

HOCl reacts with sunlight.

Hypochlorous acid (HOCl) exists in a killing form (HOCl) and as a strong oxidiser (OCl^-). The pH of water determines how much HOCl disassociates into H^+ and OCl^-. Chlorine as hypochlorous acid (HOCl) is needed for sanitisation. Chlorine as (OCl-) is needed for oxidisation.

Chlorine is most efficient at a pH of approximately 7.4 - 7.6. At low pH chlorine tends to use itself up too quickly. At a high pH chlorine doesn't produce very much disinfectant or hypochlorous acid - it is mostly in the form H^+ and OCl^- (plenty of oxidiser, low disinfectant). Pools kept at higher pH values

have more difficulty with algae and bacteria counts. The level of chlorine must be raised to compensate for this.

Hypochlorous acid is reduced to inactive chloride ion when it has done its job.

The reaction of HOCl with ammonia produces a series of chlorine-like, odorous, irritating compounds called chloramines or combined chlorine. These chloramines irritate eyes and mucous membranes and are often confused with chlorine. Combined chlorine has little ability to kill bacteria.

Free available chlorine at levels up to 10-20ppm has no detectable taste or odour and causes little or no irritation to touch. This level is not safe for swimming, however, and pools and spas should be kept below 5ppm.

Cyanuric Acid (CYA) - Chlorine Stabiliser

Ultra-Violet (UV) light degrades chlorine by a chemical reaction in which two chlorine molecules combine with two molecules of water to form four molecules of hydrochloric acid also known as hydrochloric acid plus oxygen. Without the use of cyanuric acid (stabiliser) on a bright sunny day 90% of the active chlorine can be destroyed by sunlight in just 2 hours.

The theory is that hypochlorous acid (HOCl) and hypochlorite ions (OCl^-) closely attach to one of the 3 free bonding sides of the CYA molecule. As long as they remain attached, they are not degraded by sunlight. CYA acts like a 'buffer' in that it stores chlorine and releases it to do its work on bacteria and algae. An excess of CYA in the water (over 100ppm) stores up the chlorine which is then not available to sanitise. There is some concern about the toxicity of cyanuric acid at above 100ppm.

It is recommended that you maintain a residual of 30-50ppm of CYA. At 25ppm the chlorine will last 3-5 times longer. Above 50ppm, no marginal stabilisation benefit is observed.

To achieve 50pm of CYA, add 2 kg of conditioner for each 40,000 litres of water to be protected. Stabilised chlorine products like dichlor or trichlor can cause CYA levels to rise to over 100ppm. Remove cyanuric acid from the pool water by draining/dilution or splash out and backwashing. It should be checked monthly, or after heavy rain has required the draining of some pool water. If stabilized chlorine (chlorine with CYA) is used then check the CYA more frequently.

'Liquid Chlorine' (sodium hypochlorite)

So called liquid chlorine (sodium hypochlorite, chemical formula NaOCl in NaOH (caustic soda)) is manufactured by bubbling chlorine gas through a solution of caustic soda (NaOH). At l0% available chlorine, 4 litres of liquid chlorine contains about 0.5 kg of available chlorine. Liquid chlorine, when added to water makes hypochlorous acid (the killing form of chlorine) instantly. It can be used regularly or for super-chlorination. Liquid chlorine is non-flammable and is compatible with other water-treating chemicals commonly found in a pool or hot tub.

Liquid chlorine should be stored in a cool place, shaded from sunlight. At 26°C, the available chlorine level in a jug of liquid chlorine will drop from more than 12%t to 9% in one day. At 34°C the available chlorine level will drop from 12% to 9% in just 2 hours.

Aeration and sunlight can destroy part of the available chlorine when pouring it into the pool. Pour it into the pool with the jug as close to the water surface as possible. One to two percent of the available chlorine can be lost by pouring the liquid from only 4 feet above the water's surface on a sunny, hot day. Common household liquid bleach is sodium hypochlorite, at around 1.5 percent.

Adding chlorine at a return jet or in a manner that mixes it with the water reduces the chlorine loss. If you stand in one spot while you pour the chlorine, the sunlight can begin to destroy the chlorine before it has had a chance to mix with and be protected by the cyanuric acid (conditioner). You can lose 1-2% of the available chlorine if you don't 'walk it around or mix it at a return jet'. Chlorine is more effective if added when the sun intensity has decreased.

Cyanuric acid should be added separately to keep the chlorine in the pool from being degraded by sunlight.

Calcium Hypochlorite

Cal-hypo (calcium hypochlorite, chemical formula $Ca(OCl)_2$) also called bleaching powder. It is produced by passing chlorine gas over slaked lime. Cal-hypo is stable and can be stored for long periods of time without significant loss in available chlorine level. In water it quickly forms hypochlorous acid (the killing form of chlorine).

It is supplied in granular form or as tablets. It can be used for regular chlorination as well as super-chlorination. It should be pre-dissolved in water and then added as a liquid to the pool when needed. One kg of calcium hypochlorite provides about 650-700g of available chlorine.

Cal-hypo is classified as an extreme oxidiser which is why it bleaches so well. All the other types of chlorine are classified as oxidizers with the exception of gas chlorine. Avoid mixing cal-hypo with acids, ammonia, soda pop, oil, trichlor or just about anything but water. Mixing with organics will cause a fire. Be careful when sweeping around chemical-storage areas. Mixing the dust and spillage of various products together and then putting them into a trash can or dumpster may cause a fire. Clean up product spills separately.

Cal-hypo granules and powder will temporarily cloud the water because the calcium takes a long time to dissolve completely. Cal-hypo granules sitting on vinyl will bleach the colour out of it and weaken the vinyl. You must use a feeder or pre-dissolve it in water and then add it to a vinyl-liner pool.

Depending on local water conditions, using cal-hypo will increase the hardness level by an average of 3-10ppm per month or about 1-5ppm for each kg you add to an average 5 x 10 metre pool. This may make it necessary to test the hardness level in the pool more often.

Because one kg of cal-hypo provides 0.65 kg of available chlorine, you will need 50kg of cal-hypo to get the same as 250 litres of liquid chlorine or 30kg of gas chlorine.

If the form of cal-hypo being used does not contain cyanuric acid, this must also be added separately to keep the chlorine in the pool from being degraded by sunlight.

Lithium Hypochlorite

Lithium hypochlorite (chemical formula LiOCl) is produced by bubbling chlorine gas through a solution of lithium, sodium and potassium sulphates. It is supplied as a free-flowing powder that provides 35% available chlorine.

Lithium hypochlorite is

- Calcium free (it does not harden the water).
- It is dust free and non-flammable.
- Has a long shelf life (it will lose only 0.1% of its available chlorine level per month), it dissolves rapidly without clouding.
- Can be used directly in vinyl liner pools. It dissolves very rapidly.
- It can be used for regular and super-chlorination.

- Lithium-hypo is the most expensive.

Because it dissolves so rapidly, it cannot be used in a dry-chlorine feeder. It can be pre-dissolved and dispensed in a liquid feeder.

One kg of lithium hypochlorite provides about 350g of available chlorine.

90kg of lithium-hypo produces 30kg of available chlorine.

Cyanuric acid must be added separately to keep the chlorine in the pool from being degraded by sunlight.

Sodium Dichlor

Sodium dichlor (sodium dichloro-s-triazinetrione, chemical formula $NaCl_2C_3N_3O_3$) is the only popular type of chlorine that does not require the addition of either a neutralising chemical or cyanuric acid.

Sodium dichlor is produced by adding soda ash and cyanuric acid to a solution of trichlor. When dried the result is a granule that may provide 56-62% available chlorine, depending on the method of manufacture. The 56% formulation is by far the most readily available of the two.

Sodium dichlor is fast dissolving, will not cloud the water and has a long shelf life. It can be used for regular and for super-chlorination. Because it is fast dissolving, it cannot be used in a dry chemical feeder. It should not be pre-dissolved and dispensed in a liquid chlorinator.

Sodium dichlor can cause a build-up of cyanuric acid in the pool water. It is 57% stabiliser (cyanuric acid) by weight. Cyanuric acid levels should be more frequently checked. Partial drain and refill the pool is required if the cyanuric acid level exceeds 100ppm. One kg of sodium dichlor contains slightly more than 560g of available chlorine and 570g of stabiliser.

Sodium dichlor is the second most expensive per kg of available chlorine but it does not have any hidden costs associated with it.

Sodium dichlor has a pH close to 7 (neutral) and so does not require any neutralising chemicals to be added to the water. It already contains cyanuric acid saving on this cost also.

One kg of sodium dichlor provides 560g of available chlorine.

Trichlor (Tabs)

Trichor (trichloro-s-triazinetrione, chemical formula $Cl_3C_3N_3O_3$) contains 90% available chlorine - the highest of all. Trichlor is produced by drying and cooling the sodium salt of cyanuric acid in the presence of chlorine gas.

Trichlor is mostly available as tablets, sticks or a cartridge. It has a long shelf life, and it is very slow dissolving, so it works extremely well in floaters and erosion-type feeders. It can be used for regular chlorination but not for super-chlorination because it dissolves too slowly.

The granular form can be used as a spot algaecide. Trichlor does not require the addition of cyanuric acid to the pool water. Trichlor is highly acidic (pH 2.8-3). It will corrode equipment and pool plaster if improperly used. Corroded metal, usually copper, will deposit on the pool walls as a turquoise discolouration and can cause blue fingernails and green hair for swimmers. It is necessary to add about 350g of soda ash for each kg of trichlor used.

Trichlor increases the cyanuric acid in the pool water. Cyanuric acid levels need checking more frequently. Pools should be partially drained and refilled the pool if the level exceeds 100ppm. One kg of trichlor provides 900gms of available chlorine.

35kg of trichlor will supply the 30 kg of available chlorine necessary to sanitise a typical pool of 5 x 10 metres for 1 year.

Gas Chlorine
Gas chlorine (liquefied chlorine gas, chemical formula Cl_2 is very dangerous. It is the cheapest and the most dangerous to use and store. Gas chlorine is the purest form of chlorine you can buy. There are no fillers or carriers, so half the chlorine you add to the pool water is used for disinfecting, sanitising and oxidising.

Gas chlorine causes a very acidic condition to occur in the pool as it drastically lowers the pH by the formation of hydrochloric acid (HCl) as a by-product. It is therefore necessary to add about 6kg of soda ash or 10kg of sodium sesquicarbonate for each 1kg of gas used.

Because gas chlorine does not have cyanuric acid (conditioner) in it, you must use cyanuric acid separately to keep the chlorine in the pool from being degraded by sunlight.

Super Chlorinating

Shock Treating/ Super Chlorinating
Or: burning up the pollutants with strong oxidizing chemicals

Shock treating or shocking refers to the addition of anything to the water that will remove or destroy ammonia and nitrogen compounds by oxidation - traditionally this has been chlorine. There are now some non-chlorine shock products.

Organic matter and ammonia compounds enter a swimming pool or spa from many sources. Swimmers and bathers are major contributors with their bodies giving off saliva, sweat, urine and faecal matter. Windblown dust, fertilisers, algae, leaves, twigs, certain water-treatment chemicals and rain introduce contaminants into the water.

Chlorine and bromine combine with ammonia and nitrogen compounds to form amines. Chloramines smell bad, they are eye and body irritants and they are also poor disinfectants. Bromamines do not have an odour problem and are as effective as free bromine for disinfection. Organic wastes build up and become sources of irritation.

Dealing with the problem of combined chlorine requires testing the water to see how much of the chlorine in the water is free and how much is combined. The commonly used OTO test will not perform this task. It can only tell you the total chlorine level and can't differentiate between free and combined chlorine. However, a DPD test kit or a syringaldazine test strip will do the job.

Chlorine reacts with ammonia to remove it
When chlorine is introduced into swimming pool or spa water it forms hypochlorous acid (HOCl (free chlorine)) which dissociates into H^+ and OCl^-, the degree of dissociation depends upon the pH. The OCl^- is a strong oxidiser and will oxidise the ammonia to form a combined chlorine compound known as monochloramine (NH_2Cl) and OH^-. More chlorine as OCl^- is required to continue the oxidation of the nitrogen or ammonia. If no more chlorine was in the pool or added to it, the pool or spa water would have a large amount of combined chlorine as monochloramine rather than the desired free chlorine.

As more chlorine is added, the monochloramine is now oxidised by the additional chlorine as OCl^- to form dichloramine ($NHCl_2$ + another OH^-). The dichloramine is again oxidised by OCl^- to form trichloramine (NCl_3 + another OH^-). The trichloramine is unstable and breaks down to simple nitrogen and chlorine completing breakpoint chlorination.

Super-chlorination to truly achieve the destruction of all organic waste can be very tricky. If not enough chlorine is added, the combined chlorine problem is only made worse. When this happens, eye burn and skin irritation are raised to very high and very irritating levels. If too much chlorine is added, it may take days to drop to safe levels (less than 5ppm) before bathing can be resumed.

It takes 7.6 parts by weight of chlorine to oxidise 1 part of ammonia. Other organics or products in the water will also consume some of the added chlorine so that 7.6 parts is not enough. 10 parts of chlorine for each part of ammonia is generally the required amount. Dirty and contaminated pools could take up to 25 parts or more of chlorine. As a general rule of thumb, the addition of 10 times the combined chlorine level will achieve breakpoint. In other words, if the water has 0.5ppm of combined chlorine by test, you will need to add 5ppm or more of chlorine.

Each of the popular chlorine products provides a different amount of available chlorine when added to water. In a typical 100,000 litre pool it will take about 1 kg of available chlorine to achieve 10 parts per million.

Non-Chlorine Shock

The active ingredient in these non-chlorine shock products is potassium peroxymonosulfate, also known as permonosulfate. Like chlorine, permonosulfate is an oxidiser that will destroy organic contaminants such as ammonia in swimming pools and spas. However, permonosulfate compounds do not kill or disinfect they simply control organics and combined chlorine, helping assure that the chlorine can do its job as a sanitiser. Permonosulfates oxidise by using the element from which oxidation derives its name -- oxygen.

Oxygen is a pure form of oxidiser. Unlike super-chlorination, which is used to destroy problems such as odours, eye and skin irritation after they occur, permonosulfates are effective in preventing these problems because they do not contain chlorine but rather oxidise waste through the use of oxygen. They do not go through the various stages of chloramine formation to achieve breakpoint. Instead, they react directly with the ammonia to produce chloride and nitrogen. No matter how little of the non-chlorine shock you add, at least some of the organic contaminants will be destroyed, and no additional chloramines will be formed. This overcomes one major drawback of super-chlorination.

If you overdose with a non-chlorine shock by adding more than is required, no extended waiting period is needed before swimming can be resumed. Although bathers should not be present when any chemical is added to the water, swimming can be resumed after the permonosulfate has had a chance to dissipate, usually just a few minutes. In fact, the excess chemical will remain in the water, ready to destroy any contaminants that may enter the pool from bather waste and other sources.

Permonosulfates are 100% soluble and will not leave a residue or bleach vinyl liners or swimming suits. Because they are chlorine-based, it is not necessary to calculate how much to add to beat a given chloramine problem. Permonosulfates help prevent chloramines from forming, so whatever quantity is applied will have some positive result. Unlike super-chlorination, which requires you to figure out how much chlorine to add and how often to correct problems, permonosulfates, are generally added at the rate of 0.5 kg per 35,000 litres on a regular, weekly basis.

Permonosulfates effectively control the formation of chloramines, which cause odours, reduce disinfection and cause eye and skin irritation. Permonosulfates cause an acidic condition to occur i.e. they have a low pH of about 2.3-3, so steps will need to be taken to counteract the acidic condition that may be caused by using them. Permonosulfates do not add to the calcium or other undesirable solids or cyanuric acid in the water. Also, no special handling is required, and there is no reason to close the pool or spa or to restrict swimming due to excessive chlorine residuals. Finally, there is no need to calculate how much to add in order to be effective. Permonosulfates are also safer to store and handle than chlorine products because they will not burn or release chlorine gas.

Literature cited

TPS Pty Ltd: www.tps.com.au/pools/algae