Swimming pool sanitation

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Swimming pool sanitation is the process of ensuring healthy conditions in swimming pools, hot tubs, plunge pools, and similar recreational water venues. Proper sanitation is needed to maintain the visual clarity of water and to prevent the transmission of infectious waterborne diseases.

Contents

Methods

Sanitation methods include a water filter to remove pollutants, disinfection to kill infectious microorganisms, swimmer hygiene to minimize the introduction of contaminants into pool water, and regular testing of pool water, including chlorine and pH levels.

Guidelines

The World Health Organization has published international guidelines for the safety of swimming pools and similar recreational-water environments, including standards for minimizing microbial and chemical hazards.[1] The United States Centers for Disease Control and Prevention also provides information on pool sanitation and water related illnesses for health professionals and the public.[2] The main organizations providing certifications for pool and spa operators and technicians are the National Swimming Pool Foundation and Association of Pool & Spa Professionals. The certifications are accepted by many state and local health departments.[3]

Contaminants and disease

Swimming pool contaminants are introduced from environmental sources and swimmers. Affecting primarily outdoor swimming pools, environmental contaminants include windblown dirt and debris, incoming water from unsanitary sources, rain containing microscopic algae spores and droppings from birds possibly harbouring disease-causing viruses.[4] Indoor pools are less susceptible to environmental contaminants.

Contaminants introduced by swimmers can dramatically influence the operation of indoor and outdoor swimming pools. Sources include micro-organisms from infected swimmers and body oils including sweat, cosmetics, suntan lotion, urine, saliva and fecal matter. In addition, the interaction between disinfectants and pool water contaminants can produce a mixture of chloramines and other disinfection by-products.

Pathogenic contaminants are of greatest concern in swimming pools as they have been associated with numerous recreational water illnesses (RWIs).[5] Public health pathogens can be present in swimming pools as viruses, bacteria, protozoa and fungi. Diarrhea is the most commonly reported illness associated with pathogenic contaminants, while other diseases associated with untreated pools are Cryptosporidiosis and Giardiasis.[6][7] Other illnesses commonly occurring in poorly maintained swimming pools include otitis externa, commonly called swimmers ear, skin rashes and respiratory infections.

The journal *Environmental Science & Technology* reported that sweat and urine react with chlorine and produce trichloramine and cyanogen chloride, two chemicals dangerous to human health. [1] (http://www.acs.org/content/acs/en/pressroom/presspacs/2014/acs-presspac-march-26-2014/an-answer-to-the-perennial-question-is-it-safe-to-pee-in-the-pool.html)

Maintenance and hygiene

Contamination can be minimized by good swimmer hygiene practices such as showering before and after swimming, and not letting children with intestinal disorders swim. Effective treatments are needed to address contaminants in pool water because preventing the introduction of pool contaminants, pathogenic and non-pathogenic, into swimming pools is impossible.

Many public swimming pools offer showers

A well-maintained, properly operating pool filtration and re-circulation system is the first barrier in combating contaminants large enough to be filtered. Rapid removal of filterable contaminants reduces the impact on the disinfection system thereby limiting the formation of chloramines, restricting the formation of disinfection by-products and optimizing sanitation effectiveness. To kill pathogens and help prevent recreational water illnesses, pool operators must maintain proper levels of chlorine or another sanitizer.[8][9]

Over time, calcium from municipal water tends to accumulate, developing salt deposits in the swimming pool walls and equipment (filters, pumps), reducing their effectiveness. Calcium also absorbs chlorine and prevents proper performance of added chemicals. Therefore, it is advised to either completely drain the pool, and refill it with fresh water, or recycle the existing pool water, using reverse osmosis. The advantage of the latter method is that 90% of the water can be reutilized.

Pool operators must also store and handle cleaning and sanitation chemicals safely.

Prevention of diseases in swimming pools and spas

Disease prevention should be the top priority for every water quality management program for pool and spa operators. Disinfection is critical to protect against pathogens, and is best managed through routine monitoring and maintenance of chemical feed equipment to ensure optimum chemical levels in accordance with state and local regulations.[10]

Modern digital equipment when used in conjunction with automatic chemical feeders results in stable pH and chlorine levels. Local jurisdiction may demand a wait time if chemicals are added by hand to the water so that swimmers are not injured.

Chemical parameters include disinfectant levels according to regulated pesticide label directions. pH should be kept between 7.2-7.8. Human tears have a pH of 7.4, making this an ideal point to set a pool.[11] More often than not, it is improper pH and not the sanitiser that is responsible for irritating swimmers' skin and eyes.

Total alkalinity should be 80-120 ppm and calcium hardness between 200 – 400 ppm.[12]

Good hygienic behavior at swimming pools is also important for reducing health risk factors at swimming pools and spas. Showering before swimming can reduce introduction of contaminants, and showering again after swimming will help to remove any.

Those with diarrhea or other gastroenteritis illnesses should not swim within 2 weeks of an outbreak, especially children. Cryptosporidium is chlorine resistant.[13]

To minimize exposure to pathogens, swimmers should avoid getting water into their mouths and never swallow pool or spa water.[14]

Standards

Maintaining an effective concentration of disinfectant is critically important in assuring the safety and health of swimming pool and spa users. When any of these pool chemicals are used, it is very important to keep the pH of the pool in the range 7.2 to 7.8-according to the Langelier Saturation Index, or 7.8 to 8.2- according to the Hamilton Index; higher pH drastically reduces the sanitizing power of the chlorine due to reduced oxidation-reduction potential (ORP), while lower pH causes bather discomfort, especially to the eyes. However, according to the Hamilton Index, a higher pH can reduce unnecessary chlorine consumption while still remaining effective at preventing algae and bacteria growth.

To help ensure the health of bathers and protect pool equipment, it is essential to perform routine monitoring of water quality factors (or "parameters") on a regular basis. This process becomes the essence of an optimum water quality management program.

Systems and disinfection methods

Chlorine and bromine methods

Conventional halogen-based oxidizers such as chlorine and bromine are convenient and economical primary sanitizers for swimming pools and provide a residual level of sanitizer that remains in the water. Chlorine-releasing compounds are the most popular and frequently used in swimming pools whereas bromine-releasing compounds have found heightened popularity in spas and hot tubs. Both are members of the halogen group with demonstrated ability to destroy and deactivate a wide range of potentially dangerous bacteria and viruses in swimming pools and spas. Both exhibit three essential elements as ideal first-line-of-defense sanitizers for swimming pools and spas: they are fast-acting and enduring, they are effective algaecides, and they oxidize undesired contaminants.

Swimming pools can be disinfected with a variety of chlorine-releasing compounds. The most basic of these compounds is molecular chlorine (Cl_2); however, its application is primarily in large commercial public swimming pools. Inorganic forms of chlorine-releasing compounds frequently used in residential and public swimming pools include sodium hypochlorite commonly known as liquid bleach or simply bleach, calcium hypochlorite and lithium hypochlorite. Chlorine residuals from Cl_2 and inorganic chlorine-releasing compounds break down rapidly in sunlight. To extend their disinfectant usefulness and persistence in outdoor settings, swimming pools treated with one or more of the inorganic forms of chlorine-releasing compounds can be supplemented with cyanuric acid—a granular stabilizing agent capable of extending the active chlorine residual half-life ($t_{½}$) by four to sixfold.[15] Chlorinated isocyanurates, a family of organic chlorine-releasing compounds, are stabilized to prevent UV degradation due to the presence of cyanurate as part of their chemical backbone.

Chlorine reacting with urea in urine and other nitrogen-containing wastes from bathers can produce chloramines. Chloramines typically occur when an insufficient amount of chlorine is used to disinfect a contaminated pool. Chloramines are generally responsible for the noxious, irritating smell prominently occurring in indoor pool settings. A common way to remove chloramines is to "superchlorinate" (commonly called "shocking") the pool with a high dose of inorganic chlorine sufficient to deliver 10 ppm chlorine. Regular superchlorination (every two weeks in summer) helps to eliminate these unpleasant odors in the pool. Levels of chloramines and other volatile compounds in water can be minimized by reducing contaminants that lead to their formation (e.g., urea, creatinine, amino acids and personal care products) as well as by use of non-chlorine "shock oxidizers" such as potassium peroxymonosulfate.

Medium pressure UV technology is used to control the level of chloramines in indoor pools. It is also used as a secondary form of disinfection to address chlorine tolerant pathogens. A properly sized and maintained UV system should remove the need to shock for chloramines, although shocking would still be used to address a fecal accident in the pool. UV will not replace chlorine, but is used to control the level of chloramines, which are responsible for the odor, irritation, and enhanced corrosion at an indoor pool.

Copper ion system

Copper ion systems use a low voltage current across copper bars (solid copper, or a mixture of copper and zinc or silver) to free copper ions into the flow of pool water to kill organisms such as algae in the water and provide a "residual" in the water. Alternative systems also use titanium plates to produce oxygen in the water to help degrade organic compounds.

Private pool filtration

Water pumps

An electrically operated water pump is the prime motivator in recirculating the water from the pool. Water is forced through a filter and then returned to the pool. Using a water pump by itself is often not sufficient to completely sanitize a pool. Commercial and public pool pumps usually run 24 hours a day for the entire operating season of the pool. Residential pool pumps are typical run for 4 hours per day in winter (when the pool is not in use) and up to 24 hours in summer. To save electricity costs, most pools run water pumps for between 6 hours and 12 hours in summer with the pump being controlled by an electronic timer.

Most pool pumps available today incorporate a small filter basket as the last effort to avoid leaf or hair contamination reaching the close-tolerance impeller section of the pump.

Filtration units

Sand

A pressure-fed sand filter is typically placed in line immediately after the water pump. The filter typically contains a medium such as graded sand (called '14/24 Filter Media' in the UK system of grading the size of sand by sifting through a fine brass-wire mesh of 14 to the inch (5.5 per centimeter) to 24 to the inch (9.5 per cm)). A pressure fed sand filter is termed a 'High Rate' sand filter, and will generally filter turbid water of particulates no less than 10 micrometers in size.[16] The rapid sand filter type are periodically 'back washed' as contaminants reduce water flow and increase back pressure. Indicated by a pressure gauge on the pressure side of the filter reaching into the 'red line' area, the pool owner is alerted to the need to 'backwash' the unit. The sand in the filter will typically last five to seven years before all the "rough edges" are worn off and the more tightly packed sand no longer works as intended. Recommended filtration for public/commercial pools are 1 ton sand per 100,000 liters water (10 ounces avdp. per cubic foot of water) [7.48 US or 6.23 UK gallons].

Introduced in the early 1900s was another type of sand filter; the 'Rapid Sand' filter, whereby water was pumped into the top of a large volume tank (3' 0" or more cube) (1 cubic yard/200US gal/170UK gal/770 liters) containing filter grade sand, and returning to the pool through a pipe at the bottom of the tank. As there is no pressure inside this tank, they were also known as 'gravity filters'. These type of filters are not greatly effective, and are no longer common in home swimming pools, being replaced by the pressure-fed type filter.

Diatomaceous earth

Some filters use diatomaceous earth to help filter out contaminants. Commonly referred to as 'D.E.' filters, they exhibit superior filtration capabilities.[17] Often a D.E. filter will trap waterborne contaminants as small as 1 micrometer in size. D.E. filters are banned in some states, as they must be emptied out periodically and the contaminated media flushed down the sewer, causing a problem in some districts' sewage systems.

Cartridge filters

Other filter media that have been introduced to the residential swimming pool market since 1970 include sand particles and paper type cartridge filters of 50 to 150 square feet (14 m^2) filter area arranged in a tightly packed 12" diameter x 24" long (300 mm x 600 mm) accordion-like circular cartridge. These units can be 'daisy-chained' together to collectively filter almost any size home pool. The cartridges are typically cleaned by removal from the filter body and hosing-off down a sewer connection. They are popular where backwashed water from a sand filter is not allowed to be discharged or goes into the aquifer.

Automated pool cleaners

Automated pool cleaners more commonly known as "Automatic pool cleaners" and in particular electric, robotic pool cleaners provide an extra measure of filtration, and in fact like the handheld vacuums can microfilter a pool, which a sand filter without flocculation or coagulalents is unable to accomplish [18]

Other systems

Saline chlorination units, electronic oxidation systems, ionization systems, microbe disinfection with ultra-violet lamp systems, and "Tri-Chlor Feeders" are other independent or auxiliary systems for swimming pool sanitation.


Automated pool cleaner

Consecutive dilution

A pool filtration system as described (above) is termed a "consecutive dilution" system, as a constant and consecutive stream of fresh, chlorinated, and filtered water is being continually returned to the pool as part of a process that could ultimately result in a pool with 100% newly introduced fresh water over a period of time. Of course this goal is never achieved, as there is also a constant stream of new contaminants entering the pool as subsequent sections of this article will indicate.

Skimmers

Coping apertures

Water is typically drawn from the pool via a rectangular aperture in the wall connected through to a device fitted into one (or more) wall/s of the pool. The internals of the skimmer are accessed from the pool deck through a circular or rectangle lid, about one foot in diameter. If the pool's water pump is operational water is drawn from the pool over a floating hinged weir (operating from a vertical position to 90 degrees angle away from the pool, in order to stop leaves and debris being back-flooded into the pool by wave action), and down into a removable "skimmer basket", the purpose of which is to entrap leaves, dead insects and other larger floating debris.

The aperture visible from the pool side is typically 1' 0" (300 mm) wide by 6" (150 mm) high, which intersects the water midway though the center of the aperture. Skimmers with apertures wider than this are termed "wide angle" skimmers and may be as much as 2' 0" wide (600 mm). Floating skimmers have the advantage of not being affected by the level of the water as these are adjusted to work with the rate of pump suction and will retain optimum skimming regardless of water level leading to a markedly reduced amount of bio-material in the water. Skimmers should always have a leaf basket or filter between it and the pump to avoid blockages in the pipes leading to the pump and filter.

Pool recirculation

The final link in the pool recirculation system: 'skimmer-pump-filter-returns' are the water returns.

Heaters

Other equipment which may be optioned in the recirculation system include pool water heaters. They can be heat pumps, natural gas or propane gas heaters, electric heaters, wood burning heaters, or Solar hot water panel heaters - increasingly used in the sustainable design of pools.

Other equipment

Diversions to electronic oxidation systems, ionization systems, microbe disinfectinon with ultra-violet lamp systems, and "Tri-Chlor Feeders" are other auxiliary systems for Swimming pool sanitation; as well as solar panels; are in most cases required to be placed after the filtration equipment, and are the last items before the water is returned to the pool.

Other features

Recreation amenities

Features that are part of the water circulation system can extend treatment capacity needs for sizing calculations and can include: artificial streams and waterfalls, in-pool fountains, integrated hot tubs and spas, water slides and sluices, artificial "pebble beaches", submerged seating as bench-ledges or as "stools" at in-pool bars, plunge pools, and shallow children's wading pools.

See also

- Copper ion swimming pool system
- Fountain
- Reflecting pool
- Water garden
- Water purification

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External links

- ICS 13.060.01 Water quality in general (http://www.iso.org/iso/en/CatalogueListPage.CatalogueList?ICS1=13&ICS2=60&ICS3=1&scopelist=) - A series of ISO standards
- ICS 07.100.20 Microbiology of water (http://www.iso.org/iso/en/CatalogueListPage.CatalogueList?ICS1=07&ICS2=100&ICS3=20&scopelist=)

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