Introduction

Water quality of swimming pools is essential! Regulatory provisions set the conditions for their use. The attraction and comfort of water, as well as basin and pool surroundings, impact upon the attendance and excitement of such sites.

Water contamination of swimming pools is two fold:

- Biological
- Chemical

Pollution sources

The users (namely swimmers) remain the principal source of chemical and biological contamination. In an aqueous environment, a healthy swimmer brings into the pool millions of germs originating from his skin and saliva.

It is important to keep in mind that some users are ill or recovering from illness, and they bring into the aqueous environment numerous alleged disease-causing organisms.

From a chemical standpoint, each and every swimmer has the capacity to transfer anywhere between 0.3 g to 0.6 g of organic matter. In general, this type of pollution is nitrogen-based and it mainly comes from sweat, urine and residual fecal particulates.

Last but not least, other sources of pollution such as the type of sanitizers used to disinfect the water, defective pool facilities associated with design flaws or operating crankiness.

Swimming activity related risks

Biological risks facing the swimmer:

Swimming sport and activities can lead to some elevated risks of infection. These infection outbreaks result from swallowing water and the skin and mucous membrane being exposed to the water. For information purposes, medical statistics show a 20-25% occurrence of gastro-intestinal infection and disturbance, a 25-30 % occurrence of epidermatic irritation, and a proportion of 50% comprised of ear, nose and throat irritations.

In regard to chemical risks facing the swimmer and the operating staff, one may consider the following:

The operating staff is subject to long periods of direct contact and is therefore likely to contract acute poisoning, either through ingestion or inhalation of toxic substances or compounds which are used for water treatment and the maintenance of the permanent structure (piping and hardware). Often mentioned as very toxic are the “di” and “tri” chloramines. The inhaling of those compounds by the swimmer is bound to happen, if not inevitable.

Other types of irritation have been widely documented such as dental problems and bronchial tube infections (respiratory diseases and asthma).

Repeated exposure to chlorine may also cause:

- Allergic disorders (conjunctivitis, rhinitis, laryngitis)
- Ocular diseases, ear infections (otitis)
- Sensitization to air-borne allergens
- Etc.

Published studies have also shown that baby swimmers in school swimming pools are at risk. Lung permeability has been proven. This physical change would likely be caused by the weakening of the pulmonary cellular lining.

All studies have pinpointed the risks and demonstrated the potential danger of derivatives and by-products coming from chlorine decomposition and the breakdown of organic compounds. The THM (trihalomethanes or haloforms) are particularly harmful to health. The one that is most studied is the tri-chloromethane, or chloroform, because this derived compound is categorized as being part of the 2B Group according to IARC (International Agency for Research on Cancer).

Correlations have been established between the rate of concentration of chloroform in the blood stream and urine, and prevailing concentrations in swimming pool water and ambient air. Skin absorption stands for 24% of the body burden, while the balance essentially comes from inhalation. All studies aim at checking the spectrum of THM inside the body burden: traces of chloroform, bromodichloromethane, di bromodichloromethane are bromoform are often found.

The same risks have been shown to be true for the supervising staff and workers responsible for maintenance and operations.

For the latter ones, it is not only imperative to take into account the dosage, for each type of pollution, of inhaled air per cubic meter (m^3), but also the maximum permissible daily levels.

The disinfection of water in public swimming pools, hot tubs, spas, and other water basins

Chlorine is generally used in its liquid state: liquid bleach 12% or sodium hypochlorite solution, trichloroisocyanuric acid, and dichloroisocyanurates. Other sanitizers can be used such as calcium hypochlorite or chlorine gas, or in some cases, molten salt electrolysis.

Chlorine, once it is in contact with water, produces hypochlorous acid, in accordance with the following chemical reactions:

$Cl_2 + H_20 \rightarrow HClO + H+ + Cl^-$

or

$NaCO + H_2O \rightarrow HClO + Na + OH^-$

Hypochlorous acid breaks down in water, and creates hypochlorite ions:

$HClO \rightarrow H^+ + Cl0^-$

Hypochlorous acid is the active form of chlorine = disinfecting agent. However, the hypochlorite ion is less active. Both of these components make up free chlorine. It can be easily measured with DPD reagents.

Water pH values determine the splitting between hypochlorous acid and hypochlorite ions.

Chlorine impact on organic matter

The effect of chlorine is very significant on proteins, ammonia, urea, etc. The result is the formation de mono, di and tri chloramines, as well as other chlorinated organic substances, which make up combined chlorine.

The various reactions are as follows:

$HOCL + NH_4OH \rightarrow NH_2Cl + 2H2O$
Monochloramine: No irritating odor in water

$HOCL + NH_2Cl \rightarrow NHCl_2 + H2O$
Dichloramine: offensive odor, irritating in water

$HOCL + NHCl_2 \rightarrow NCl_3 + H2O$
Trichloramine: volatile, repulsive odor, irritating in air.

On must take note that the development of these reactions is associated with the actual ratio between chlorine and nitrogen, the prevailing pH value, the hydrolysis and the interaction of all substances present in the water.

Overall, the percentages of the type of developed chloramine can be estimated as follows:

- Monochloramines: 70-80%
- Dichloramines: 10-15%
- Trichloramines: 5-10%

The value range of toxicity for all three types of chloramines is as follows:

- Monochloramines: 1
- Dichloramines: 10
- Trichloramines: 100

Furthermore, chlorine also reacts with nitrogen-free substances by generating irritating and toxic products (haloforms). Chloroform is one of them.

The physico-chemical properties of chloroform and trichloramine explain why these products end up in the ambient air, with greater concentrations, rather than gathering in pool waters.

Ambient air treatment of indoor pools

Numerous studies on ambient air quality document this problem. In essence, the pollutants found are trichloramines or nitrogen trichloride, chloroform, formaldehyde and phenols.

The user or operator threshold limit value, for tri chloramines, is 0.5 mg/m^3.

The short term maximum permissible exposure limit should not exceed 1.5 mg/m^3.

Facilities such as water falls, cascade falls, water slides, wave pools and spas generate abundant atmospheric aerosols which, in turn, lead to the diffusing of pollutants into the air.

The providers of air treatment and dehumidifying devices offer partial solutions for the treatment of ambient air, but do not address the problem of trichloramines which are, in effect, recycled into the air. Those proposed curative technologies are merely means of air filtration/absorption over a specific layer medium (i.e.: activated carbon).

Those technologies should be used as polishing filtration solutions, not as main air treatment solutions, for fear of fast depletion of the media (i.e.: activated carbon). Finally, setting an adequate air renewal rate is essential to guarantee effective ventilation and comfort, within the perimeters of the pool or pools.

The UVTECH solution

The best technical solution lies in the reduction effort at the very source of the pollution. UVTECH provides UV generators with medium pressure lamps, capable of maintaining low rates of contaminants, namely chloramines, well below the permissible thresholds generally accepted.

Generators boasting an optimal design and their proper staking out on the frontline of treatment will ensure the stable control or the reduction of THM concentrations.

Depending on the flow rates of water to be treated, we propose adaptive solutions with multi-lamp intermediate pressure UV generators. These equipments may be equipped, if need be, with hand-operated or automatic cleaning processes. The cleaning systems of quartz sleeves are either mechanical or chemical.

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