Swimming pool atmosphere & structural corrosion

Production of tri-nitrogen chloride and a solution to the problem

No more sore eyes and clean clear water, with an atmosphere safe to breath that avoids building corrosion

Benefits of AFM

- 80% reduced chlorine consumption
- Cryptosporidium control
- Reduced bacterial risk
- Solids removal down to sub micron levels
- Lower THM levels
- Reduce or eliminate trichloramines
- Life cycle cost benefits, water & energy give a return in capital in under 18 months
- 100% environmentally sustainable

Application for AFM

- Drinking water
- Tertiary treatment of sewage effluent
- Industrial waste water and grey water
- Swimming pools
- Desalination pretreatment
- Cooling towers
- Public aquaria

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Swimming pool air quality & structural corrosion of the building

The atmosphere in health clubs and swimming pool buildings are amongst the most corrosive environments for a building structure, especially when stainless steel materials are used. In 1985, 12 people were killed in Uster, Switzerland when the concrete roof of a swimming pool collapsed after only thirteen years. The Federal Materials Testing Institute, based in Duebendorf, Switzerland, and the Federal Materials Research and Testing Institute of Berlin concluded that the collapse was the result of chloride-induced Stress Corrosion Cracking (SCC). Every year there are serious structural failures reported for European for swimming pool buildings, in addition there can also be corrosion of ducts in HVAC systems, acid erosion of concrete, damage to electrical circuits, such as the telephone system and computers which costs the industry millions of Euros every year.

The problems are a product of the warm humid environment with a high concentration of chloride in the atmosphere. However where does the chloride come from and why is it in the atmosphere? These are simple questions but they have never been properly answered.

When chlorine is added to water, it reacts to form a pH dependent equilibrium solution of hypochlorous acid hypochlorite ions. However when you enter a swimming pool environment the chemical that gives swimming pools their characteristic smell is not chlorine but a volatile gas called tri-nitrogen chloride (trichloramine), which is acidic and corrosive. It is likely that tri-nitrogen chloride is responsible for causing the structural problems in swimming pools. Tri-nitrogen chloride has also been implicated in causing occupational asthma among pool staff, and lung damage to children attending swimming pools.

Tri-nitrogen chloride is formed by a reaction between chlorine and ammonium under acidic conditions in the water. Indeed the pH of the water needs to be less than pH 5 for tri-nitrogen chloride to form. However swimming pools are always maintained at a precise pH between pH 6.8 and 7.6, so how can tri-nitrogen chloride be formed?

Chlorine is a very effective disinfectant which kills most bacteria within a period of 30 seconds in the water. However when the bacteria are fixed to a surface (biofilm) they become almost totally resistant to chlorine. If you slide your finger across the surface of the tiles, if it feels slippy then this is due to a bacterial film. While the pH of the swimming pool water is between 6.8 and 7.6, the pH of the micro environment on the surface of the biofilm will be acidic. The principle location for the production of tri-nitrogen chloride is therefore on the surface of the biofilm.

The pool surfaces, tiles, and pipe work have a high surface area, all of which will be coated by a bacterial layer, but by far the largest surface area in contact with the water is the sand in the sand filters. One metric tonne of sand has a surface area of approximately 3000 square meters. In a standard 25m pool there will be in the region of 20 tonnes of sand which gives a surface area of 60,000 square meters. Tri-nitrogen chloride formation therefore occurs predominantly on the sand inside the sand filters.

If a swimming pool is designed properly with a good filtration system in accordance to the German DIN standards, and operated at the correct water flow rate, the water quality and atmospheric air quality will be greatly improved. The use of ozone systems and UV irradiation will improve water quality but both processes generate volatile chlorine reaction products which affect air quality. Water quality is important, but the air quality is even more important for the building, and from a public health perspective. It is therefore recommended that UV irradiation and ozone systems are not used in chlorinated systems.

The production of tri-nitrogen chloride is directly related to the surface area in contact with the water and the degree of biofouling on the surfaces, so if you eliminate the bacteria you eliminate the problem. Good hygiene is essential to control bacteria, and every effort should be taken to minimise the introduction of bacterial food, such as phosphates which can enter via the mains freshwater supply. Chemicals used in pool treatment can also contain phosphates. Surfactants used by the pool staff for cleaning the side of the pool represent another source of phosphates. The choice of chemical products and the cleaning regime should be chosen with care, and under no circumstances should cleaning chemicals containing anionic surfactants and phosphates be allowed to enter the water. It is also essential that the public shower before entering the pool, preferably without the use of shampoo or soap. Indeed the building should be designed such that it is impossible for the public to avoid the showers before entering the pool.

The recent appreciation of the role bacteria play in the production of the corrosive volatile gas tri-nitrogen chloride has led to the development of new technology. Filtration media designed to replace sand in sand filters has been developed that rejects bacterial growth. One such media is Active Filter Media (AFM). When biostatic media is used in place of the sand the biomass of bacteria is greatly reduced, and thereby the production of tri-nitrogen chloride is reduced.

Products that remove phosphate and bacterial nutrients, (NoPhos) and dissolved organic matter (PAC) should be injected into the water prior to the AFM filters. These products coagulate dissolved bacterial nutrients, and then flocculate the coagulated particles into larger particles which makes it easier for the filters to remove. The role of coagulation and flocculation is therefore absolutely essential in swimming pool systems to maintain both water and air quality.

Diatomaceous and perilite filters are being considered for use in swimming pool water treatment systems. While the filters are very effective at removing solids from the water, coagulation and flocculation chemicals can not be used because the chemicals rapidly block the filters. Coagulation and flocculation can be used with AFM filters, but over the last 30 years the average velocity of the water through media filters has been increased from 15m/hr to 30m/hr in an effort to save costs and space in the plant rooms. Media bed filtration performance varies inversely proportionally to the water flow rate, and at the higher water flows coagulation and flocculation chemicals are not as effective. It is therefore important that the water flow rate through media bed filters is reduced to at least 15m/hr .

The lack of appreciation of the role played by bacterial biofouling has led to some serious flaws in the design of swimming pool water treatment systems over the last 30 years, and this has caused the problems that we are now experiencing. Building structures are being compromised and the health of the pool staff and public are being affected. However give an understanding of the mechanism of tri-nitrogen chloride production, the solution to the problem is both elegant and simple. Slow media bed filtration should be employed using a biostatic filter media such as AFM, coupled with NoPhos & PAC coagulation and flocculation to reduce bacteria nutrients. Short cuts should not be taken with the size and quality of the filtration system, and the staff should be proficient and qualified. By taking these simple measures the water quality will be optimised and the atmosphere will be much safer for the public and the building.