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# Environmental Health Technical Brief

## *Indoor Air Pollution at Indoor Swimming Pools*

Environmental & Occupational Health Assessment Program

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Indoor swimming pools found in hotels, water parks and other recreational facilities can pose health risks to the swimmers and lifeguards if the water and air quality are not managed properly. The two published cases cited below exemplify the problems that can arise.

Case: In December 2006, an otherwise healthy 6 y/o boy and his family spent 3 hours swimming in the indoor pool at a motel in Nebraska. During this time he had an onset of coughing and shortness of breath. He stopped playing in the pool but his cough worsened over the next 5 hours. He became agitated with increasing respiratory distress and was taken to a local ED. The boy was admitted to the pediatric intensive care. The attending physician recorded chlorine irritation as the cause of the breathing difficulty. His case was part of an outbreak in which multiple people reported burning eyes and nose, congestion and cough. Subsequent follow-up by CDC found poor water and air quality at this pool. The full account can be found at:
MMWR: http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5636a1.htm

Case: In 2007, over a period of several months, multiple reports of respiratory and eye irritation were received by the health district from patrons and lifeguards at a hotel indoor water park in Ohio. Lifeguards reported significantly more symptoms particularly on days of high occupancy. The facility contained 11 water slides, 2 activity pools, 2 hot tubs, a wave pool, a leisure river and several features that splash, spray and aerate large amounts of water. An investigation found water chemistry to be within state standards, however, the air samples showed increased levels of trichloramine. The full account can be found at:
MMWR: http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5804a3.htm

# How Pools Become A Breathing Hazard

Free Chlorine + Nitrogen = Chloramines

The chlorine used to disinfect swimming pools combines with nitrogen compounds from swimmers in the form of perspiration, urine, personal care products, skin flakes, nasal discharge, and fecal matter. This forms the disinfection by-products, chloramines. There are several types of chloramines: monochloramine, dichloramine, and trichloroamine. Trichloroamine ($NCL_3$) is the main chloramine found in the air above chlorinated pools. It is more volatile and thus more readily released into the air than the other chloramines producing a powerful odor. It is formed more rapidly when the water has a low pH and a high chlorine/nitrogen ratio and when there are many bathers in the pool. It is a strong irritant on the skin, eyes, nose and throat. In addition to causing breathing problems, chloramines are poor disinfectants.

Chloroamine levels in the air are affected by the water chemistry, the amount of fresh air being circulated, and the aerosolizing of the contaminants when the water is sprayed or splashed.

# Air & Water Quality

Air and water quality are dependent on each other. High chloramines in water leads to high chloramines in the air. The air above the pool water needs to be assessed and managed as carefully as the water.

## Ventilation

The ventilation system must be able to remove contaminants and moisture and provide a supply of outdoor air at an exchange rate in accordance with ASHRAE (American Society of Heating, Refrigerating & Air Conditioning Engineers) guidelines through a properly designed distribution system.

ANSI/ASHRAE 2007 provides ventilation rate guidelines of:

- 0.5 cfm/$ft^2$ sq ft of indoor pool & deck areas; OR
- 15 cfm/occupant [cfm = cubic feet per minute]

The air exchange rate (rate at which indoor air is exchanged with outdoor air) and the ventilation air rate (total amount of air being supplied through the HVAC system, including recirculated air) are key factors contributing to the effectiveness of the ventilation system. Other factors include the exhaust air flow rates, the location of the air returns, the air movement across the pool surfaces, and the maintenance of the dehumidification system, if present.

Poor movement of fresh air over the pool surface will cause the air to get saturated with chloramines so that new chloramines being produced cannot off-gas. These irritants will accumulate in the water creating an unhealthy environment.

### Indications of Air Quality Problems

- Condensation on windows and walls (fog/wetness)
- Mold growth (discoloration on ceiling and walls)
- Damage to building envelope (rot, corrosion)
- Atypical/pungent chemical odor; Strong chlorine odor
- Cloudy water

## Water Chemistry

pH should be maintained between 7.2 and 7.8

Free chlorine should be kept at a minimum of 0.8 ppm, not to exceed 3 ppm

Combined chlorines (chloramines) should be <0.2 ppm

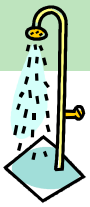
Testing: A test to detect chloramines is not readily available. Tests can be done using a colorimetric or spectrometric test kit to determine total chlorine and free chlorine. The combined chlorine levels can then be calculated.

Combined Chlorines = Total Chlorine - Free Chlorine

If the combined cloramine level > 0.2 ppm, the system should be shocked. Shocking (superchlorination) involves using a 10 x concentration of chlorine in the pool to raise the free chlorine level in the pool to the "break point" to initiate a chemical reaction that converts the chloramines back to free chlorine, nitrogen gas and water. This releases the ammonia leaving free chlorine in the pool. Ventilation should be increased after shocking to remove the nitrogen gases.

**A well maintained pool should have little or no disinfectant odor and should not cause swimmers to have burning eyes.**

# Prevention Measures



Owner: Assure adequate ventilation, provide training in water chemistry and ventilation to operators; promote good hygiene by providing convenient access to showers; provide toilet and hand washing facilities that are easily accessible from the pool.

Pool operator: Maintain ventilation system, monitor humidity and temperature, monitor air exchange rates, test and adjust pool chlorine and nitrogen concentration, pH, temperature and water circulation patterns.

Employees/Lifeguards: Enforce showering/using bathroom before entering pool; notify operator if you experience symptoms, notice problems with pool clarity, odors, or if there are reports of health symptoms.

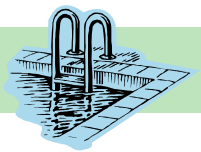
Swimmers & Parents: Ensure children/self shower before entering the pool, encourage frequent bathroom breaks; be aware of symptoms; report any symptoms, odors, water clarity issues to pool staff.

LHD: Inspect the pools. The Public Health Code states that inspections must be done by the director of health or his agent. DPH recommends an annual inspection. During inspection take note of disinfection odors, mold & moisture and the water chemistry results recorded in the log. Investigate outbreaks.

Physicians: Recognize symptoms associated with patient visits to indoor pools/water parks.

**Importance of Showers:**

- The nitrogen load swimmers bring into the pool is a large contributor to the problem.
- The amount of nitrogen can be decreased by showering before entering the pool.
- Showers should be placed on the way to the pool from the locker room.
- Signs shall be posted reminding swimmers that they are required to shower first.



# Alternatives/New Technologies

Ozone can be used as a secondary disinfectant system. Installing an ozone system requires an initial higher capitol cost but reduces the operating and maintenance costs over the long term. Ozone is a more powerful oxidant than chlorine. The ozone is made and used on site with an ozone generator. Ozone systems do not produce chloramines.

Ultraviolet (UV) disinfectant systems can be used to lower the chlorine levels and are often used as a supplement to the use of chlorine.

A balance must be achieved between reducing chlorine levels to reduce chloramines production and subsequent health problems and maintaining adequate disinfectant levels to meet state and national disinfectant standards and prevent infectious diseases.

# Resources and References


- *Irritants (Chloramines) & Indoor Pool Air Quality, CDC*:

  http://www.cdc.gov/healthywater/swimming/pools/irritants-indoor-pool-air-quality.html

- *Swimmer, Protect Thyself: Cleaning Up the Pool Environment*, Spivey, A Environ Health Perspect. 2010 November; 118(11): http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2974719/

- *Childhood Asthma and Environmental Exposures at Swimming Pools: State of the Science and Research Recommendations*, Weisel, CP. et al. Environ Health Perspective:

  http://ehsehplp03.niehs.nih.gov/article/fetchArticle.action?articleURI=info%3Adoi%2F10.1289%2Fehp.11513

- *Occupational asthma caused by chloramines in indoor swimming-pool air*, Thickett, KM et al. European Respiratory Journal 2002; 19: http://erj.ersjournals.com/content/19/5/827.full

- NSPF Pool-Spa Operator Handbook http://nspf.org/en/products.aspx

- Ozone Disinfectant Systems:

  http://www.professionalswimmingpools.com/2011/03/ozone-disinfectant-systems

- *The Relationship Between Pool Water Quality and Ventilation***.** Emanuel, BP. Environmental Health, 1998: http://www.thefreelibrary.com/_/print/PrintArticle.aspx?id=21125872

- *Chemical Off-Gassing from Indoor Swimming Pools*, Cavestri, RC, June 2008; ASHRAE 1083-RP: http://rp.ashrae.biz/page/RP1083.pdf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