

SWIMMING POOL AIR

ARE YOUR STAFF AT RISK?

CHRIS BIENSCH



HVAC, AIR CIRCULATION & CUSTOMER SERVICE

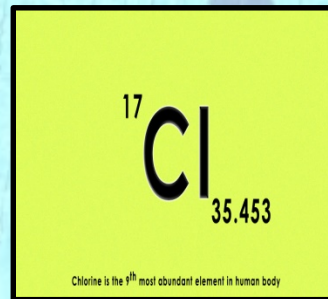
- Air is an invisible customer service indicator.
- Customers and staff will seldom compliment how good it makes them feel – it should be invisible.
- Customers will complain if it is not invisible, or there is an odour. Staff will sometimes, start, then stop because of ‘nose-blindness.’
- In persistent cases of poor air quality, staff can be at risk, and customers do not generally return.
- Some staff develop irritative respiratory symptoms (asthma, nasal or ocular sensitivities to pool air. . .)

SWIMMING POOL CHEMISTRY

trichloramines
(airborne)



+

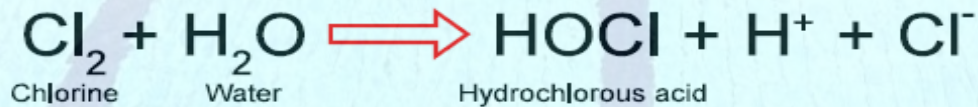


Disinfection
Byproducts (DBPs) -
mono, dichloramines,
trihalomethanes
(in the water)

*'85% of the chlorine used associates with
oxidation, not disinfection'*

DISINFECTION BYPRODUCTS

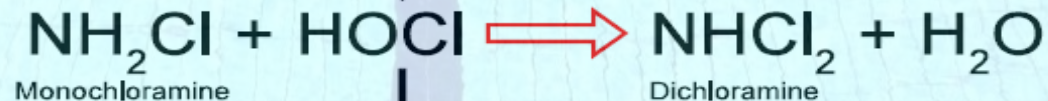
FORMATION OF CHLORAMINES FROM AMMONIA



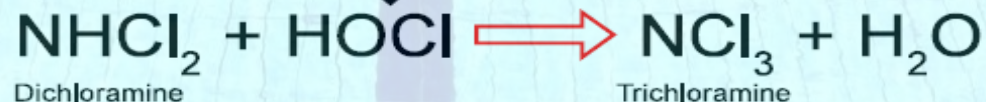
Monochloramines



Dichloramines



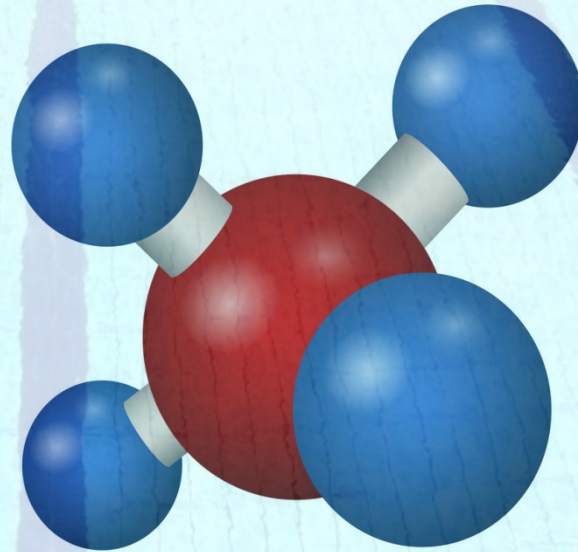
Trichloramines



Chemical formation of chloramines

DISINFECTION BYPRODUCTS

FORMATION OF TRIHALOMETHANES FROM CARBON AND METHANE



‘Hydrogen atoms are displaced by chlorine to form the halomethane’

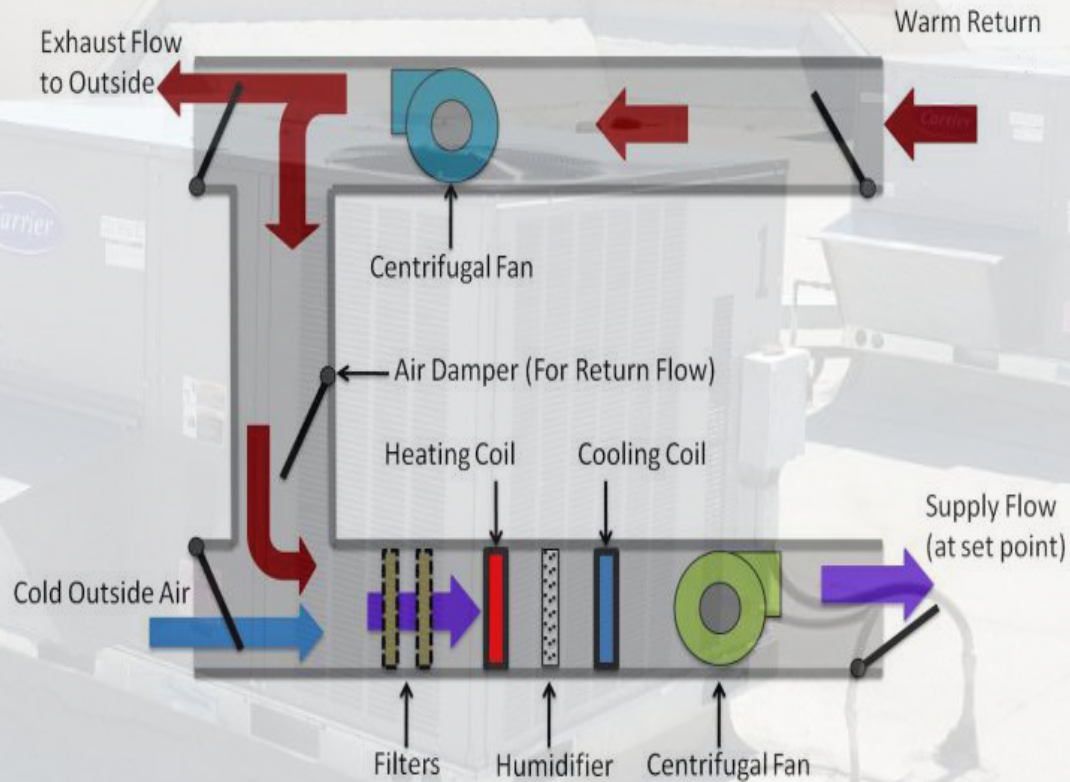
DISINFECTION BYPRODUCTS

TRIHALOMETHANES

Common trihalomethanes (ordered by **molecular weight**)

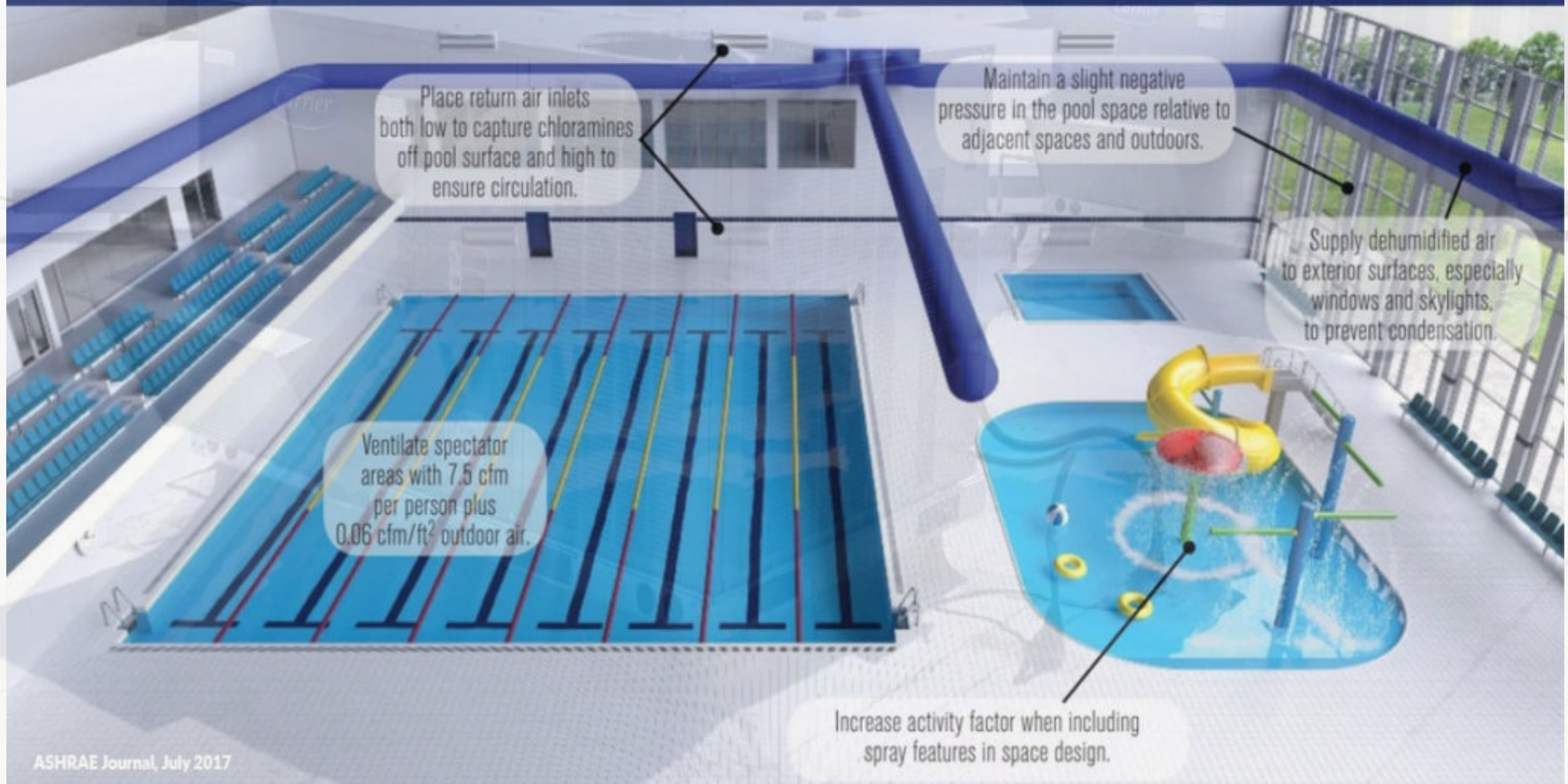
Molecular formula	IUPAC name	CAS registry number	Common name	Other names	Molecule
CHF ₃	trifluoromethane	75-46-7	fluoroform	Freon 23, R-23, HFC-23	
CHClF ₂	chlorodifluoromethane	75-45-6	chlorodifluoromethane	R-22, HCFC-22	
CHCl ₃	trichloromethane	67-66-3	chloroform	R-20, methyl trichloride	
CHBrCl ₂	bromodichloromethane	75-27-4	bromodichloromethane	dichlorobromomethane, BDCM	
CHBr ₂ Cl	dibromochloromethane	124-48-1	dibromochloromethane	chlorodibromomethane, CDBM	
CHBr ₃	tribromomethane	75-25-2	bromoform	methyl tribromide	
CHI ₃	triiodomethane	75-47-8	iodoform	methyl triiodide	

HVAC BASICS



ASHRAE RECOMMENDED POOL

FIGURE 1 Creating a healthy space and protecting it from corrosion requires delivering sufficient outdoor air to all microzones including spectator areas, the breathing zones of swimmers and people on the deck, exterior surfaces, and upper levels of the space.



SOURCE CAPTURE DBPs ASHRAE

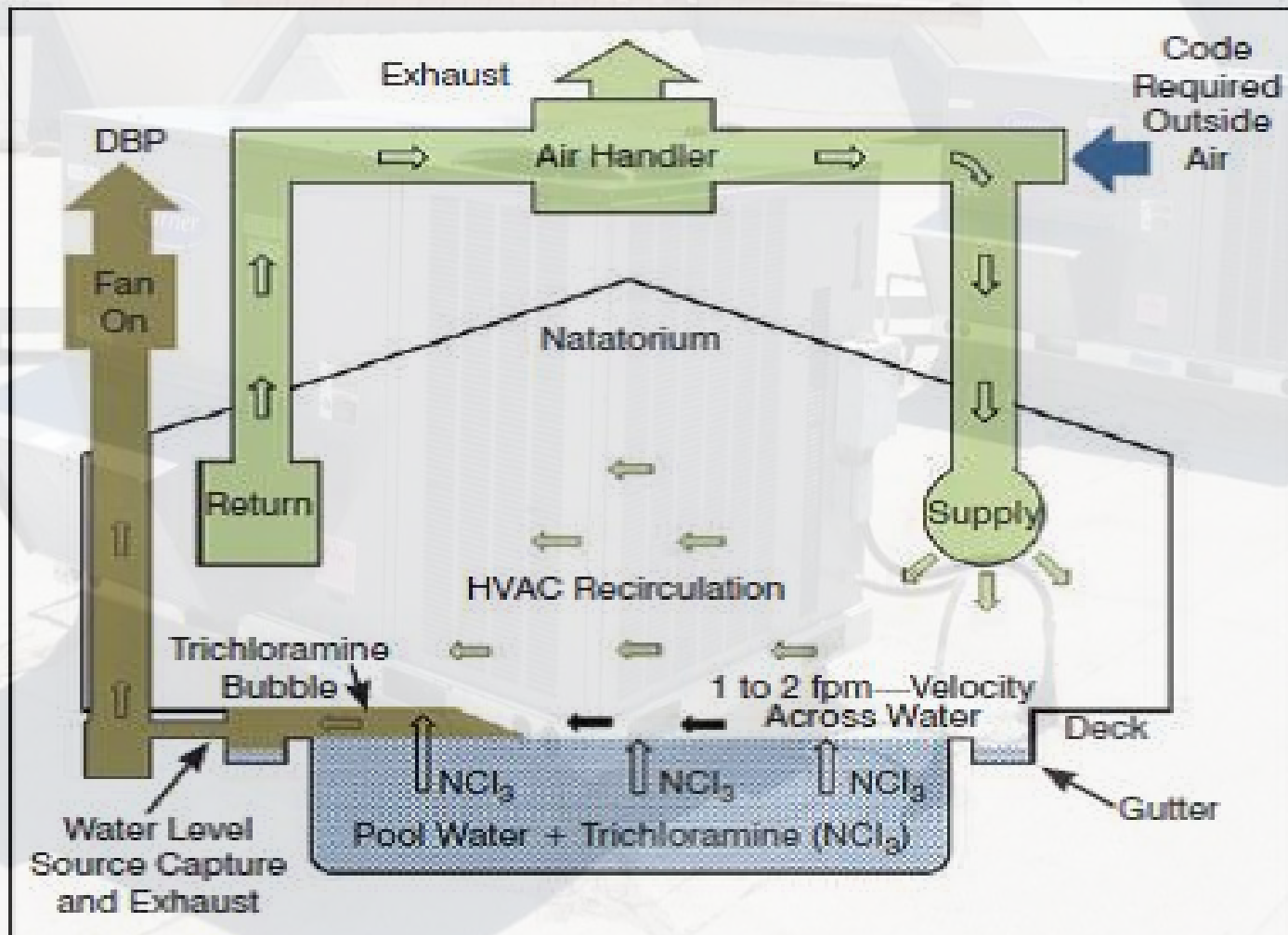


Figure 1: Source capture and exhaust strategy.

DESIGN RECOMMENDS WORLDVIEW

- **AIR TURNOVER:**
 - ❖ **ASHRAE** recommends 4 – 6 turnovers for regular (TOs. recreation, and 6 – 8 TOs for competition pools.
 - ❖ **PWTAG** U.K. is 6 – 8 TOs.
 - ❖ **DIN** is 8 – 10 TOs.
 - ❖ the **2018 MAHC** (U.S.) defers to ASHRAE.
 - ❖ Designers use median 8 TOs.

DESIGN RECOMMENDS WORLDVIEW

- **FRESH AIR SUPPLY:**
 - ❖ **ASHRAE 2.4 L/s per square metre** of pool and wet deck space.
 - ❖ **PWTAG (UK) 12 L/s per person occupying the space** – further recommends another **10% when water feature** are on.
 - ❖ **PWTAG also no less than 30% outside air** infused
 - ❖ **AARFP Pool Ops 20% recommended industry standard.**
- **MECHANICAL AREAS:**
 - ❖ **ASHRAE = dedicated HVAC and exhaust esp. where chemical dosing occurs.**

DESIGN RECOMMENDS WORLDVIEW

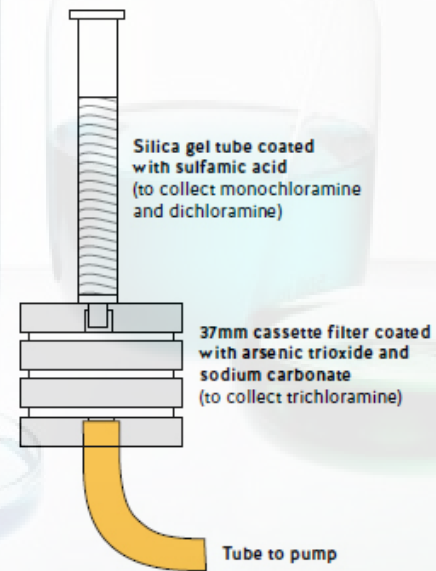
- **NATATORIUM PRESSURE BALANCE:** All design documents recommend a slightly negative air pressure to handle the heated, humid air.
- **SURGE / BALANCE TANKS:** Ensure proper venting to the outside (high off-gassing, dirtiest water in facility); accessible and clean-friendly; use basin coating material to reduce biofilm contact (i.e. tile or epoxy – seal concrete with pool paint at very least)
- **ACCESSIBLE BULK HEAD DESIGN:** trap doors for cleaning

DBP CONSIDERATIONS (TRICHLORAMINE, THMs)

- **Disinfection Byproducts (DBPs)** including trichloramines (NCl_3), trihalomethanes (THMs), specifically trichloroform (CHCl_3) are always present in to some degree in pools.
- **Trichloramines (NCl_3)** are volatile (breathed in), **trichloromethanes (CHCl_3)** not volatile (they are absorbed).
- Over **240** other **DBPs** have been studied. Schmalz, C. et al., 2011 Jour of Water and Health Germany, Application of an Optimized System for the Exp of Human Lung Cells to NH_3
- Only method of measuring NCl_3 until recently has been tube tests.

DESIGN CONSIDERATIONS (DBPs, TRICHLORAMINE)

- **TRICHLORAMINE TUBE TEST:** performed only by certified Occupational Hygienists – the test is run in the area suspected for a period of time.



Apparatus for chloramine sampling

DESIGN CONSIDERATIONS (DBPs, TRICHLORAMINE)

- **MECHANICAL / PLANT ROOMS:** especially those with surge or balancing tanks will off-gas NCl_3 into the staff area – though ASHRAE is silent, ensure 100% outside air if possible – could be combustion air (we design public spaces well; not so much plant/mechanical/staff).



STUDIES . . . THE BASICS

- 1000's of scholarly studies on DBPs in the last decade.
- **CORRELATION** is not **CAUSATION**.
- Hypothesize **STATISTICAL** significance.
- **EVALUATE** them (when consumed) who funded? Were they peer reviewed? Were the results published independently?
- Assess them as to how it relates to the answer you are seeking.

STUDIES SHOW . . .

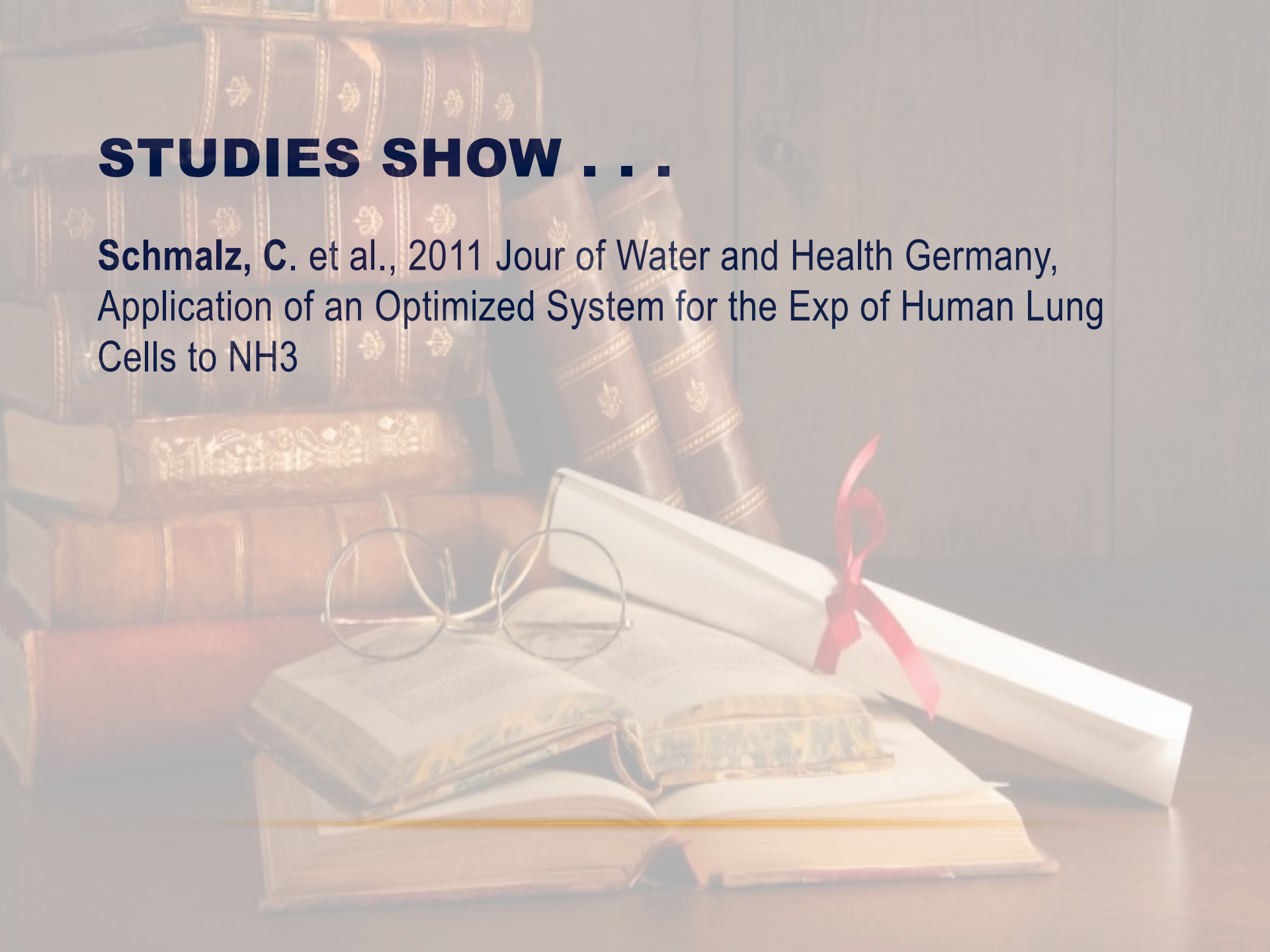
- **Jacobs, Spaan: 2007 European Resp Journal, Exposure to Trichloramines and Resp Symptoms in Indoor Pool Workers** – long term Dutch pool workers studied; higher risk of respiratory symptomology at 0.56 mg/m³ (stat. sig.)
- **Jacobs, et al.: 2012 Occ Environ Medicine, Swimming Pool Attendance and Resp Symptoms among Dutch Children** – children were unaffected
- **Fantuzzi, G. et al: 2013 Journal of Exp Health and Enviro Epidemiology, Airborne Trichloramine Levels and Self Reported Symptoms** – Lifeguards and trainers higher risk of ocular and upper resp tract irritations levels 0.5 mg/m³

STUDIES SHOW . . .

- **Parrat et al., 2012 Brit Occ Hygiene Soc, Assessment of Occ and Public Exp to Trichloramine in Swiss Indoor Pools –** French levels at 0.5 mg/m^3 but significant symptomology occurred $0.2 - 0.3 \text{ mg/m}^3$. (DOES AB NEED A LIMIT?)
- **Manasfi et al., 2017 IJ of Hygiene and Enviro Health, Occurrence, Origin, and Toxicity of DBPs in Pools an Overview** - meta analysis of 150 previous papers – THMs, HALs, HANs in ppb, ppt range with significant cell effect – mutagenic or carcinogenic.

STUDIES SHOW . . .

Schmalz, C. et al., 2011 Jour of Water and Health Germany,
Application of an Optimized System for the Exp of Human Lung
Cells to NH₃



DO I HAVE A PROBLEM?



DO I HAVE A PROBLEM?



DO I HAVE A PROBLEM?



DO I HAVE A PROBLEM?

HOW TO TEST?

- **Smell threshold of NCl_3 is approximately 0.05 mg/m^3**
(if your staff or customers smell it, there may be a problem!!)
- Get some testing done by a qualified professional.
- Have instrumentation staff test the balance of the pool hall to be SLIGHTLY negative .



WHAT CAN I DO? (DBPs REDUCTION)

RECOMMENDATION

- **SHOWER PROTOCOL:** the CDC has demonstrated that a one-minute cleansing shower removes 90% of contaminants.
- **ON DECK CLEANING PRODUCTS:** ensure non-ammonia based cleaning products used on deck and in lockerooms such as hydrogen peroxide.
- **FILTERING and DILUTION SYSTEMS:** Strive to operate the filtration systems to the maximum benefit, testing turbidity often; dilute with fresh water via an intentional program. Clean gutters, skimmers, surge tanks and filters regularly, and on a program.

WHAT CAN I DO? (DBPs REDUCTION)

RECOMMENDATION

- **NON-CHLORINE BASED OXIDIZERS:** potassium monopersulphates or chlorine dioxide products (most of the chlorine used is for oxidation, not disinfection).
- **SUPPLEMENTARY OXIDATION SYSTEMS:** ultraviolet light and ozone systems can reduce DBPs – exercise caution when sourcing.
- **DESIGN CONSIDERATIONS OF NEW BUILDS:** oversize fans by 10-15% for the pool hall and mechanical air systems; ventilate surge / balance tanks, coat them with basin material & make them easily cleanable (isolation valves, sanitary drains, access ports)

WHAT CAN I DO? (DBPs REDUCTION)

RECOMMENDATION

- **FAC TARGET REDUCTION:** by keeping the FAC lower, DBPs are reduced – make an intentional plan to deal with DBPs while water-borne.
- **EDUCATE, EDUCATE, EDUCATE:** trichloramine is NOT elemental gas chlorine – would the latter come out of your tap?
- **BULKHEADS AND SKIMMERS:** keep these clean, clean, clean. Scrub with degreaser on a program.

WHAT CAN I DO? (DBPs REDUCTION)

RECOMMENDATION

- **AIR TESTING:** consider performing air-borne DBP testing by a professional where you believe there may be a problem.
- **AIR HANDLING SYSTEMS:** inspect air-handling systems for all facility including pool hall and mechanical areas

WHAT CAN I DO? (DBPs REDUCTION)

RECOMMENDATION

- **ARPA CONFERENCE RESOLUTION:** ARPA voted on a resolution at their AGM (Oct. 25, 2018) to standardise testing, recognise and to establish OH&S exposure limits of pool staff to NCl_3 – thanks for the support! There's more to come
- **EMPLOYEE WELLNESS:** Purchase low-calorie breakfast pastries for brunch every week; has little to do with air, but keeps employees happy.

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https://www.engineeringtoolbox.com/pressure-converter-d_825.html

DESIGN INDOOR AQUATIC FACILITIES

<http://www.innoventair.com/Portals/3/Breathe%20Content/Ventilation-and-air-distribution-in-indoor-aquatic-facilities.pdf>

https://www.desert-aire.com/sites/default/files/Brochure-21st-Century-Pool-Design-Guide-DA030.pdf_0.pdf

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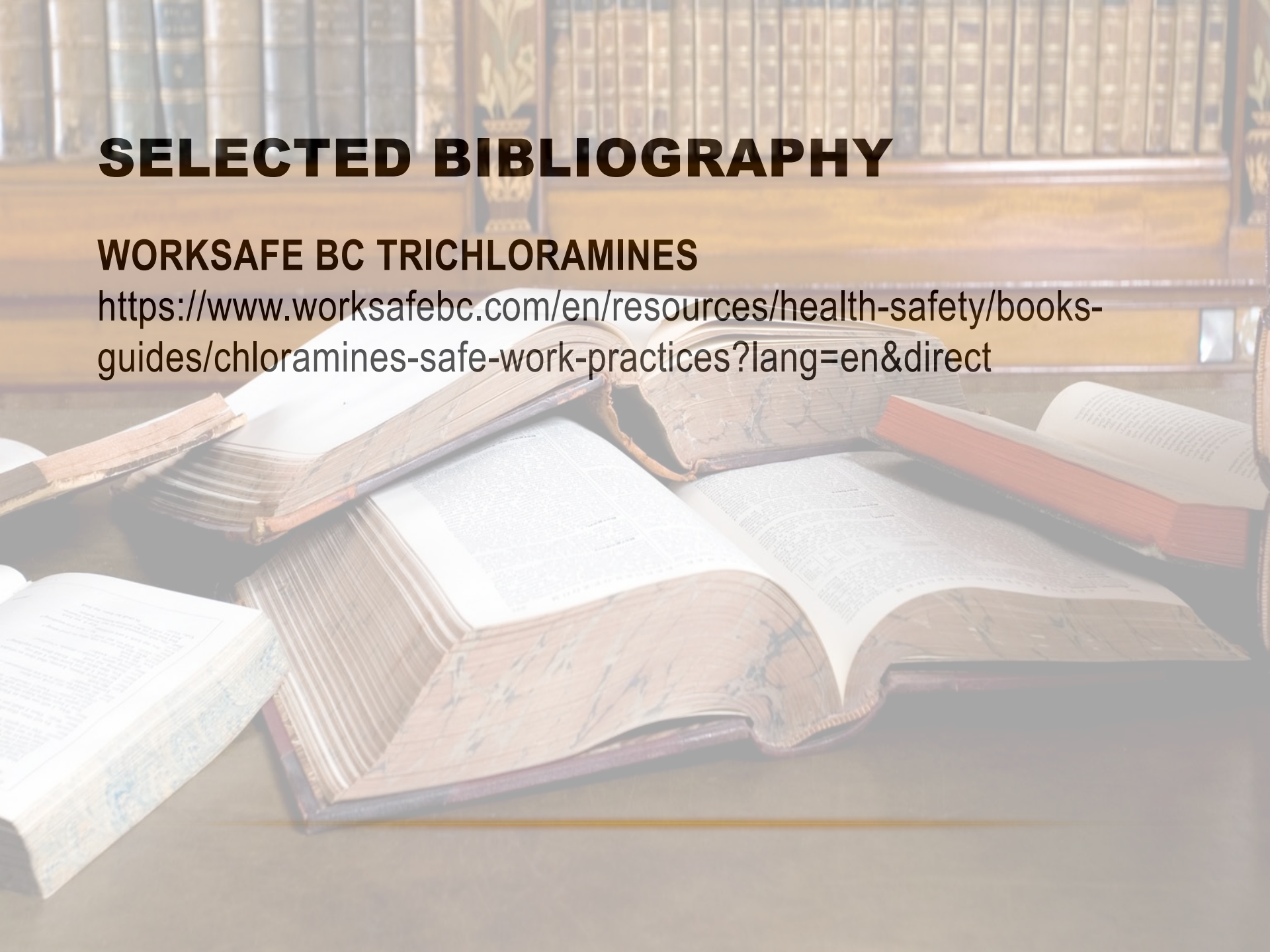
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<https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards>

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THANK YOU FOR YOUR TIME

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DBPREDSTRAT



