







# PROFESSIONAL CERTIFICATE IN AQUATIC FACILITY OPERATIONS

## *MODULE 9: POOL AIR QUALITY AND ENVIRONMENTAL SYSTEMS*

*Your ticket to employment*

POOL & SPA TRADE SCHOOL
EST 2024

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# 9.1 Understanding Indoor Air Quality in Aquatic Facilities



The water in a pool can look perfect and still be hiding a silent hazard: the air above it. For indoor pools, air quality is as vital as chlorine residuals. Operators who ignore ventilation systems often end up managing not water, but symptoms: red eyes, coughs, corrosion, and complaints.

## Defining an Emergency

Poor air quality is both a health and compliance issue under Ontario's Health Protection and Promotion Act and the Occupational Health and Safety Act (OHSA). The goal of this topic is to explain how air interacts with water chemistry, what affects it, and how operators can maintain it within safe, comfortable limits.

## The Composition of Air in Pool Environments

Indoor pool air is a complex mix of:

- Fresh supply air from HVAC systems
- Moisture and evaporation from the water surface
- Chemical gases, primarily chloramines and carbon dioxide
- Heat from water, patrons, and equipment

Each component affects comfort and safety. When balance shifts, such as too much humidity, not enough ventilation, or elevated chloramines, the result is irritation, corrosion, and potentially regulatory non-compliance.









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## Legal and Public Health Framework

In Ontario, no single regulation sets a numeric air quality limit for pools, but several overlapping standards guide compliance:

- **Ontario Regulation 565 – Public Pools** requires proper ventilation and humidity control in enclosed pools.
- **OHSA** mandates safe indoor air where workers are not exposed to harmful contaminants.
- **ASHRAE Standard 62.1 – Ventilation for Acceptable Indoor Air Quality** provides design criteria commonly used by engineers and inspectors.

Together, these require that pool facilities maintain:

- Adequate outdoor air exchange
- Humidity between 50–60 %
- Air temperature 1–2 °C higher than water temperature (to reduce evaporation)



Operators who monitor and document these parameters demonstrate due diligence even in the absence of a strict numeric regulation.

## The Relationship Between Water and Air

Water and air form a single ecosystem. Every splash releases disinfectant by-products; every chemical dose alters the balance. Chloramines, the gases responsible for the "pool smell, "form when chlorine reacts with nitrogen compounds from sweat, urine, and cosmetics. These heavier-than-air gases settle close to the water surface, irritating eyes, throats, and lungs. High chloramine levels also corrode metal fixtures and deteriorate ductwork.

Poor water chemistry therefore becomes poor air quality. The operator controls both by:

- Maintaining proper free chlorine and pH
- Ensuring regular water turnover
- Running ventilation continuously during occupied hours
- Avoiding shock dosing while swimmers are present









## Measuring Air Quality

While Ontario does not require continuous air monitoring, responsible facilities track several indicators:

| Parameter | Target Range | Impact If Out of Range |
|---|---|---|
| Relative Humidity | 50–60 % | Corrosion, condensation, microbial growth |
| Air Temperature | 1–2 °C above water | Excess evaporation, discomfort |
| Carbon Dioxide ($CO_2$) | < 800 ppm | Fatigue, poor ventilation |
| Combined Chlorine in Air | < 0.5 ppm equivalent | Irritation, odour |
| Airflow Direction | Supply from dry to wet zones | Odour migration, uneven temperature |

Operators can use handheld meters or building management data.

Recording weekly values in the logbook shows inspectors that environmental control is active, not assumed.

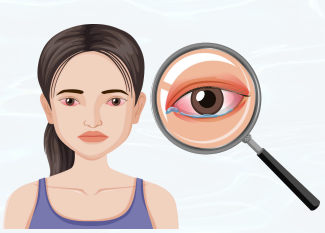








## Recognizing Symptoms of Poor Air Quality





**For Patrons and Staff**

- Eye or throat irritation
- Coughing, wheezing, or “swimmer’s cough”
- Fatigue or headaches during shift

**For the Facility**






- Corrosion on light fixtures and ductwork
- Rust stains near return air grilles
- Condensation on windows even during moderate humidity
- Persistent chlorine odour despite correct water chemistry

When these signs appear, the air system, not just the water, requires testing and adjustment.

## Scenario: The Morning Cough

Lifeguards report coughing during early shifts. Chlorine and pH readings are perfect, but ventilation fans had been shut off overnight to “save energy.”

Air tests show high combined chlorine levels near the surface. Continuous ventilation reinstated; symptoms vanish.

**Lesson:** Energy saved through shortcuts is lost again through complaints and corrosion. Air quality never sleeps.













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## Airflow and Circulation Principles

Proper ventilation depends on airflow pattern more than just volume. Supply diffusers should push clean, dry air across the water surface toward exhaust grilles located low on the opposite wall. This cross-flow removes contaminants where they form.



Common faults include:

- Return vents placed too high, trapping chloramines near the surface
- Supply diffusers blowing directly onto swimmers, causing discomfort
- Blocked or dirty filters reducing airflow

Operators should verify air direction with simple methods such as tissue tests or smoke pens during monthly maintenance checks.

## The Operator's Responsibilities

Although HVAC systems are often maintained by contractors, operators are responsible for:

- Daily observation of air quality and humidity
- Logging any odour, condensation, or discomfort complaints
- Ensuring contractors hold current HVAC certifications
- Keeping maintenance reports and filter-replacement records
- Coordinating with Public Health when persistent air issues occur

Under the OHSA, failure to report poor air conditions that cause illness can be treated as neglect of worker safety.









## Scenario: The Rusting Railings

After a year of operation, deck railings and light fixtures show rust. Investigation finds humidity levels averaging 75 % and return air fans clogged with lint. Maintenance replaces filters and adjusts dehumidifier settings; corrosion halts.

**Lesson:** Air is invisible until it leaves marks. Maintenance records are the fingerprints of diligence.

## Maintaining Balanced Environments

Stable air quality depends on consistent control of three variables:



1. **Temperature:** Maintain air 1–2 °C warmer than water.
2. **Humidity:** Use dehumidifiers or HVAC to hold 50–60 %.
3. **Airflow:** Verify direction and velocity monthly.

During chemical dosing, increase ventilation temporarily. Keep doors and windows closed during winter to avoid condensation, but never at the expense of airflow.

## Communication and Monitoring



Integrate environmental checks into the operator's daily round:

- Record air temperature and humidity with each chemical test.
- Report persistent odour or haze to supervisor immediately.
- Schedule HVAC filter cleaning and coil inspection monthly.
- During inspections, show records to Public Health or building maintenance.

By documenting environment as carefully as water chemistry, operators demonstrate total system awareness, a key element of professional certification.









## Reflection Exercise

Walk through your facility (or imagine one you know) and identify at least three indicators of air quality. Record answers in your learning journal.

1. What do you see or smell?

2. How would you verify the ventilation system is working?

3. What documentation could you show to prove due diligence if questioned by an inspector?

## Summary

Air quality is the mirror of water quality. A clear pool beneath a hazy ceiling is not a success story; it's a warning. Balanced air protects health, equipment, and energy efficiency. The professional operator watches the invisible as carefully as the visible, knowing that what patrons breathe matters as much as what they swim in.









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# 9.2 Chloramines and Chemical Interactions

Most people describe the “pool smell” as the scent of chlorine. In reality, it’s the smell of failure, the chemical footprint of incomplete disinfection. That sharp odour comes from chloramines, compounds formed when free chlorine reacts with nitrogen-based contaminants such as sweat, urine, and skin cells.



Chloramines are more than a nuisance. They cause eye and throat irritation, corrode metal fixtures, and create poor indoor air quality. Understanding how they form, how to measure them, and how to control them is essential for every certified pool operator.

## What Are Chloramines?

Chloramines are combined chlorine compounds. When chlorine (hypochlorous acid, HOCl) oxidizes ammonia or organic nitrogen, the process produces three main types:

| Type | Chemical Formula | Relative Irritation | Notes |
|---|---|---|---|
| Monochloramine | $NH_2Cl$ | Mild | Forms first; some disinfectant ability |
| Dichloramine | $NHCl_2$ | Moderate | Produces odour, eye irritation |
| Trichloramine (Nitrogen Trichloride) | $NCl_3$ | Severe | Volatile gas; main irritant above water |









Trichloramine is responsible for the characteristic “chlorine smell.” It escapes from the water surface into the air, irritating mucous membranes and damaging metal and HVAC systems.



## The Chemistry of Formation

Chlorine sanitizes by oxidizing contaminants. When organic waste or ammonia is abundant, chlorine is consumed faster than it can oxidize completely. The reaction stalls at intermediate stages, producing chloramines instead of achieving full oxidation to nitrogen gas.

Key precursors include:

- Ammonia ($NH_3$) from urine, sweat, and decomposition of urea
- Amino acids from body oils, lotions, and skin
- Nitrogen-based cleaners occasionally introduced during maintenance

Every swimmer introduces between 0.5–1.0 mL of perspiration and trace urea per minute of activity. In a busy pool, this equals litres of organic waste each hour, ample fuel for chloramine formation.

## Measuring Combined Chlorine

Combined chlorine (CC) represents the portion of total chlorine locked in chloramine compounds. It’s calculated as: **CC = Total Chlorine – Free Chlorine**

For public pools under Regulation 565, combined chlorine should remain below 0.5 mg/L. Readings above that threshold indicate contamination buildup or poor oxidation.









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## Testing Tips



- Use DPD test kits with accurate colour matching.
- Test twice daily or more during high bather load.
- Record all results in the operational log.
- Investigate readings above 0.5 mg/L promptly; persistent elevation signals the need for breakpoint chlorination.

## Breakpoint Chlorination

Breakpoint chlorination is the process of adding enough chlorine to destroy chloramines and fully oxidize contaminants. It occurs when a sufficient chlorine dose converts all combined chlorine into harmless nitrogen gas and water.

The rule of thumb:
Add 10 times the amount of combined chlorine measured.

Example:
If combined chlorine = 0.6 mg/L, add ≈ 6 mg/L of free chlorine equivalent.

Steps:

1. Raise chlorine to breakpoint concentration.
2. Maintain pH 7.2–7.4 for optimum reaction.
3. Circulate continuously for 24 hours.
4. Test until combined chlorine < 0.5 mg/L.
5. Reopen pool only after residual stabilizes within legal limits.

Operators must document the process (dosage, times, and readings) as evidence of proper remediation.









## Scenario: The Friday-Night Odour

By closing time Friday, swimmers complain of strong "chlorine smell." Tests show free chlorine = 1.0 mg/L, total = 2.2 mg/L (CC = 1.2). The operator initiates breakpoint chlorination to 12 mg/L overnight. Saturday morning readings: free = 3.0, total = 3.3, CC = 0.3 mg/L.

**Lesson:** The smell disappears not by adding fragrance, but by restoring chemistry.

## The Role of Ventilation



Even with perfect chemistry, trichloramine still forms in trace amounts. Good ventilation removes it before concentration rises. Air-exchange systems should provide 4–6 air changes per hour, drawing fresh air across the water surface toward low-level exhaust.

When ventilation is reduced to "save energy," chloramine gas accumulates, irritating staff and patrons. Operators must ensure HVAC runs continuously during pool hours and for at least 30 minutes after closing.

## Oxidation Technologies Beyond Chlorine

Modern facilities supplement chlorine with secondary oxidation systems to prevent chloramine build-up:

- **UV (Ultraviolet) Systems** — Break down chloramine molecules through photolysis; often installed in return-water lines









- **Ozone Generators** — Provide powerful oxidation, converting ammonia to nitrogen

- **Advanced Oxidation Processes (AOP)** — Combine ozone and UV for maximum effect



These systems reduce combined chlorine but never replace routine testing or disinfection.

Ontario Public Health inspectors recognize UV and ozone as acceptable adjuncts when maintained and documented.

## Scenario: The UV Upgrade

An indoor therapy pool struggled with persistent combined chlorine ~ 0.8 mg/L despite regular shocking.

Installation of a medium-pressure UV reactor dropped readings to 0.2 mg/L within two weeks.

Staff reported improved air quality and reduced odour complaints.

**Lesson:** Secondary oxidation pays for itself in clearer water and quieter lungs.





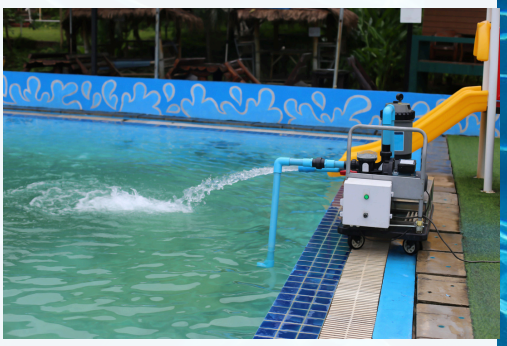




## Managing Source Contamination

Because chloramines begin with human waste, prevention starts before chemistry.





### Bather Hygiene Measures

- Mandatory pre-swim showers using soap.
- Enforcement of illness exclusion policies (no swimming within 48 hours of diarrhea).
- Signage reminding patrons of hygiene importance.
- Proper use of swim diapers for infants.

### Operational Measures

- Increase water turnover during high-load sessions.
- Schedule shock treatments after heavy use.
- Monitor and clean gutters, filters, and deck drains.

Each action removes organic matter before chlorine has to fight it.

## Environmental and Structural Effects

Trichloramine corrodes metals and degrades finishes. Long-term exposure causes:

- Rusting of ladders and ceiling supports
- Pitting of stainless steel
- Degradation of electrical fittings
- Paint discolouration



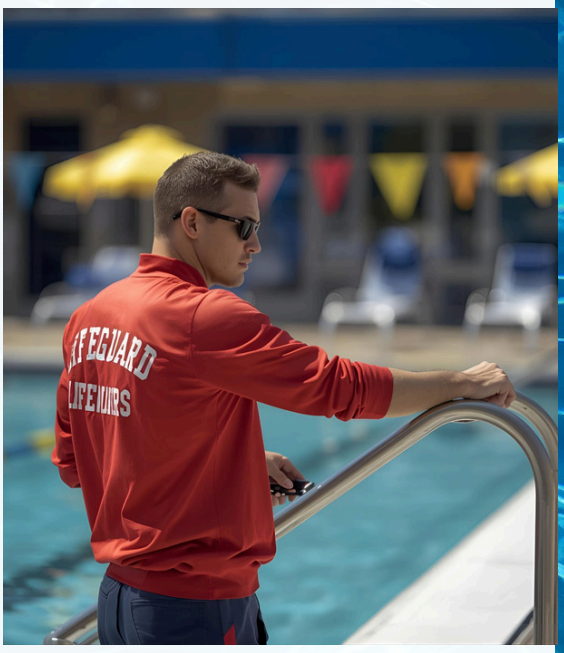






Regular inspection and cleaning of ceilings and ductwork prevent deterioration. Use corrosion-resistant materials (316 stainless or coated aluminium) for fixtures in high-humidity zones.

## Worker Health Considerations



Persistent chloramine exposure can cause occupational asthma or "lifeguard lung." Under the OHSA, employers must protect staff from chemical irritants.

Operators should:

- Monitor and record air quality complaints.
- Maintain ventilation and chemical logs.
- Report repeated symptoms to supervisors or JHSC.
- Include chloramine control in WHMIS and respiratory hazard training.

## Scenario: The Persistent Cough

Two lifeguards develop chronic coughs. Investigation shows combined chlorine 1.1 mg/L and $CO_2$ > 1 000 ppm. Ventilation fans had failed.

Once repaired, symptoms resolve. Public Health commends prompt action and new daily ventilation log.

**Lesson:** Worker health is the canary of compliance. Every cough tells a chemical story.

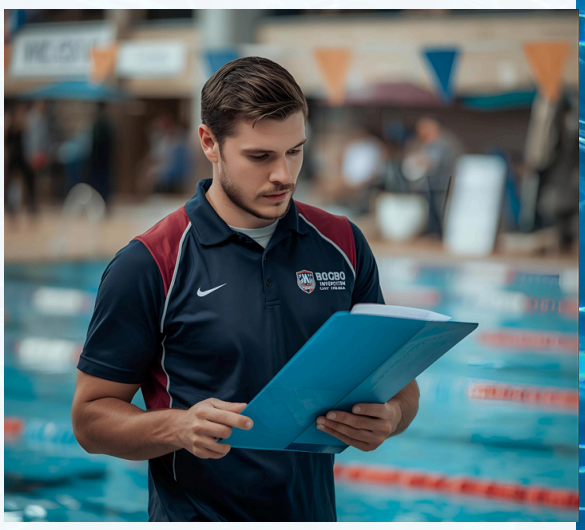








## Integrating Air and Water Testing



To control chloramines effectively:

- Test free and total chlorine every 2 hours during peak use.
- Log humidity and air temperature alongside water readings.
- Conduct monthly air sampling for combined chlorine in large facilities.
- Record ventilation run times and filter maintenance dates.

This integrated log demonstrates that both sides of the pool ecosystem are managed in tandem.









## Reflection Exercise

Review your facility's recent logs or imagine a sample dataset:

- Free chlorine: 1.4 mg/L
- Total chlorine: 2.1 mg/L
- Combined chlorine: ?
- pH: 7.6
- Humidity: 70 %

Write your answers in your learning journal.

1. Calculate combined chlorine.

2. Identify what the data suggest about air and water quality.

3. Recommend two corrective actions.









## Summary

Chloramines are a symptom, not a mystery. They tell the operator that organic load is winning the chemical war.

By understanding the chemistry, maintaining ventilation, and enforcing hygiene, the professional operator turns the “pool smell” back into silence.

Healthy air begins with clean water; clean water begins with attentive people.









# 9.3 Ventilation, Humidity, and Temperature Control



Good air doesn't just happen. It's engineered, balanced, and maintained every day by the pool operator who understands that comfort, safety, and efficiency all share the same airflow. Ventilation, humidity, and temperature together shape how patrons experience the space and how long the building itself survives. A clear pool with stale air is still a failure of management.

## The Purpose of Ventilation

Ventilation has three goals:

1. Remove airborne contaminants, such as chloramines, carbon dioxide, and humidity-laden air.
2. Supply fresh oxygenated air for bathers and staff.
3. Control condensation and protect building materials.

Under Ontario Regulation 565 – Public Pools, operators must maintain "adequate ventilation and humidity control" in enclosed pools.

The Occupational Health and Safety Act adds the duty to keep the workplace free from harmful exposure. In practice, that means mechanical systems must exchange indoor air often enough to prevent odour, haze, or condensation.

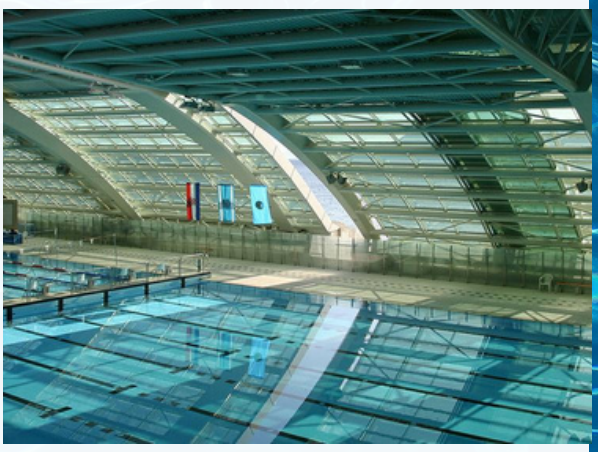








## How Ventilation Works in Pool Environments



An aquatic HVAC system does more than heat or cool. It simultaneously:

- Introduces outdoor air through supply ducts
- Circulates conditioned air across the water surface to strip humidity and chloramines
- Removes exhaust air through low-level grilles or rooftop fans
- Recovers heat from outgoing air to improve energy efficiency

A well-designed system provides 4–6 air changes per hour and directs air from dry to wet zones; for example, from viewing areas toward the pool deck and finally out through exhaust vents near the water line.

When the system falls out of balance, heavy gases such as trichloramine linger at deck level, producing eye and throat irritation.

## Temperature Relationships

Temperature management follows one simple rule:
Keep air temperature 1–2 °C warmer than water temperature.

This slight differential suppresses evaporation. If the air is cooler than the water, moisture rises rapidly, overloading dehumidifiers and creating fog or condensation.









Recommended operating ranges for most Ontario public pools:

| Parameter | Typical Range | Notes |
|---|---|---|
| Air Temperature | Water + 1–2 °C | Prevents evaporation and chills |
| Water Temperature | 27–29 °C (lap) / 30–34 °C (therapy) | Maintain consistent comfort |
| Relative Humidity | 50–60 % | Above 65 % → condensation; below 40 % → dry air irritation |

Operators should verify these values at least daily and record them beside chemical readings.

## Humidity Control

Humidity is moisture suspended in the air. Pools produce enormous amounts through evaporation.

Each swimmer can add more than 200 grams of water vapour per hour. If this vapour isn't removed, it condenses on cold surfaces such as windows, causing mould, rust, and decay.











## Immediate Actions



Dehumidifiers and air handling units (AHUs) keep humidity in check by:

- Cooling moist air to condense and drain water
- Reheating the dry air before returning it to the space
- Integrating sensors that modulate fan speed and compressor load

## Operator Responsibilities

- Inspect condensate drains weekly to prevent overflow.
- Clean coils quarterly; dust acts as insulation and reduces efficiency.
- Replace or clean filters monthly.
- Ensure sensors are calibrated annually.

Humidity control isn't just about comfort; it's structural insurance.

## Scenario: The Dripping Ceiling

After several months of "minor" condensation, a facility notices rust spots on ceiling bolts and warped acoustic panels. Investigation finds humidity averaging 70 %, with the dehumidifier's condensate line blocked. Clearing the line and cleaning coils restore proper balance.

**Lesson:** Water in the air becomes water in the roof. Maintenance is cheaper than reconstruction.

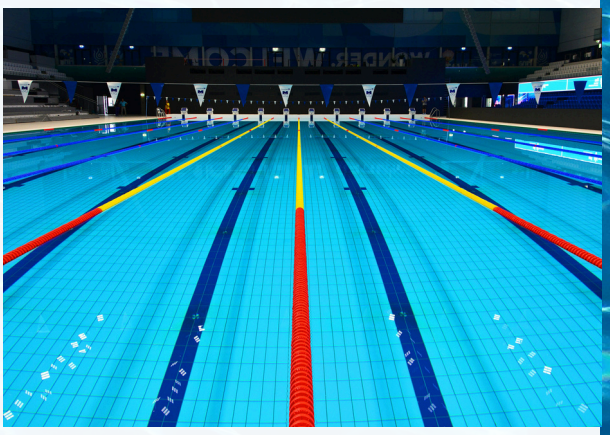








## Airflow Patterns and Distribution



Airflow must sweep contaminants away from breathing zones. Ideal pattern:

- Supply air introduced high along side walls, angled toward water surface
- Return air collected low on the opposite side near deck level
- Air velocity over water: 15–30 cm/s, enough to move vapour without chilling swimmers

Operators should verify direction monthly using light tissue or smoke pens. If tissue hangs still or moves erratically, adjust diffuser angles or request mechanical service.

Common airflow faults:

- **Short-circuiting:** Supply air goes directly into return vent, skipping pool surface.
- **Dead zones:** Corners where air stagnates, producing odour pockets.
- **Down drafts:** Cold air blowing directly onto water or patrons.

## Scenario: The Odour Corner

Patrons complain of smell near shallow end. Tissue test reveals dead zone where air circulation is poor. Technician adjusts diffuser vanes and increases fan speed; odour disappears within hours.

**Lesson:** Sometimes the difference between complaint and compliance is the angle of a grille.



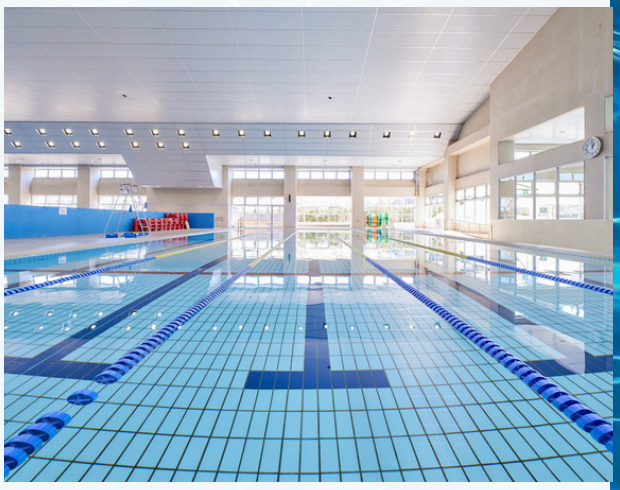






## Coordination Between Water and Air Systems

Because evaporation drives both humidity and chloramine release, ventilation can't be managed in isolation.



- Maintain correct water temperature and chemistry (pH 7.2–7.6, free chlorine 1–3 mg/L).
- Ensure circulation systems run continuously during pool hours.
- Increase fresh air intake during heavy bather load or after shock dosing.
- Monitor combined chlorine levels. Rising values often signal insufficient ventilation.

Think of the water system and HVAC as two lungs breathing together; if one fails, the other gasps.

## Maintenance Schedules

A structured schedule protects both compliance and equipment lifespan.

### Daily

- Record air temperature and humidity.
- Observe for condensation, odour, or haze.
- Check that exhaust fans and dehumidifiers are running.



### Weekly

- Clean vent grilles and return filters.
- Inspect visible ductwork for corrosion.
- Verify condensate drains are clear.







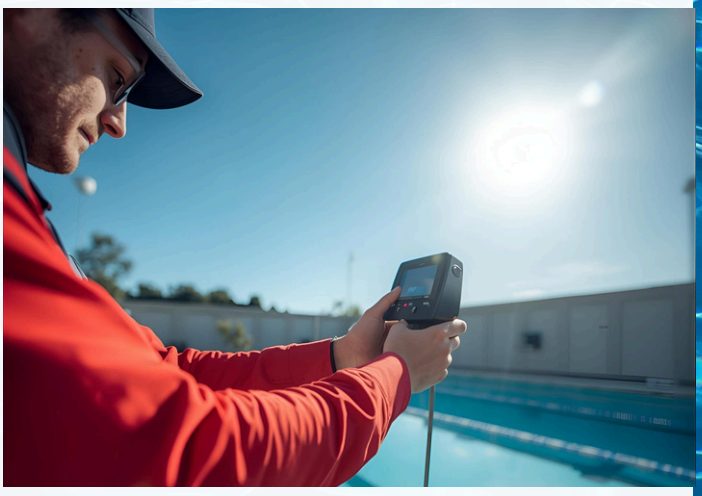


**Monthly**

- Replace air filters if disposable.
- Inspect belts and fan bearings.
- Test airflow direction and velocity.

**Annually**

- Have certified HVAC technician calibrate sensors, clean coils, and test air exchange rate.
- Review energy recovery performance and adjust set points.



Keep all service reports in your facility's Environmental Systems Logbook. During Public Health inspections, these logs show continuous attention rather than reactive maintenance.

## Energy Efficiency and Cost Balance

Ventilation consumes significant energy. However, reducing air exchange to "save power" often increases humidity and corrosion costs. Energy efficiency comes from balance, not restriction.

Operators can support sustainable performance by:

- Ensuring heat-recovery systems function (inspect exchangers quarterly).
- Keeping filters clean to minimize fan strain.
- Maintaining correct temperature differentials to reduce evaporation load.
- Scheduling equipment runtime through building automation controls rather than manual shut-offs.

A system that breathes steadily costs less than one that gasps for air.









## Scenario: The Night Shut-Off

To cut utility bills, management programs HVAC shutdown overnight. By morning, humidity has condensed on ductwork; rust streaks appear within weeks. Energy audit later shows corrosion repairs cost three times the savings.

**Lesson:** Airflow is cheaper than replacement steel.




## Safety and Regulatory Considerations

Under the OHSA, air quality issues affecting worker health, such as chloramine inhalation, mould, or carbon monoxide from gas heaters, require prompt reporting to supervisors and possible Ministry investigation.

Every air handling failure is both a mechanical and an occupational health event.

## Documentation and Reporting

Environmental data should appear in the same logbook as water chemistry. Each entry demonstrates integrated control. Logs should include:

- Date/Time
- Air Temp (°C)
- Humidity (%)
- Comments/Issues
- Action Taken
- Operator Initials
- Filter Change Dates
- Coil Cleaning Confirmations
- Technician Service Reports
- Calibration Certificates for Humidity and Temperature Sensors

During inspection, these records show not only that the pool is safe today but that it's been safe for months.









## Reflection Exercise

Consider your facility or a pool you know.

1. Where are supply and exhaust vents located relative to the water?

2. Do you notice condensation or smell at certain times of day?

3. How could you verify that humidity sensors are accurate?

4. Write a short paragraph describing one improvement you would recommend to enhance air system performance.









## Summary

Ventilation, humidity, and temperature are invisible until they fail. The professional operator keeps them balanced through vigilance, not guesswork. Air that feels comfortable, smells clean, and leaves metal shining is proof of unseen discipline, the daily act of adjusting, recording, and maintaining equilibrium between water and air.


# 9.4 Environmental Monitoring and Corrective Measures



Air quality and environmental control don't rest on intention alone. They rely on monitoring, documentation, and decisive action. A professional operator treats environmental readings the same way they treat chlorine tests: measurable, recordable, and actionable.

Topic 9.4 explains how to track the invisible variables that define pool safety and comfort, and how to respond before problems escalate into corrosion, illness, or public-health non-compliance.

## The Purpose of Environmental Monitoring

Monitoring bridges the gap between what operators feel and what inspectors require. It serves three functions:

**1. Verification** — proving that air and environmental systems perform as designed









**2. Early warning** — detecting trends such as rising humidity or $CO_2$ before they cause damage

**3. Accountability** — documenting a pattern of diligence that satisfies both OHSA and Public Health Ontario expectations

Environmental logs become the evidence of competence. When a complaint arises, an operator who can produce months of consistent readings turns a potential citation into a demonstration of professionalism.




## Parameters to Measure

The key variables mirror those covered in previous topics but are now integrated into one diagnostic routine. Each value represents a control lever. When two or more drift from target, system balance is lost. Logs should capture readings alongside comments ("slight haze – increased fan speed").

| Parameter | Recommended Range | Monitoring Method | Frequency |
|---|---|---|---|
| Air Temperature | 1–2 °C above water | Digital thermometer or BMS sensor | Daily |
| Relative Humidity | 50–60 % | Hygrometer, psychrometer | Daily |
| $CO_2$ Concentration | < 800 ppm | Handheld $CO_2$ meter | Weekly or continuous |
| Airflow Direction | Dry → wet zones | Smoke pen/tissue test | Monthly |
| Combined Chlorine (Air sample) | < 0.5 ppm equivalent | Passive sampler or lab test | Monthly |
| Noise Levels (optional) | < 85 dB in plant rooms | Sound meter | Quarterly |









## Monitoring Tools and Technology



Modern facilities blend manual checks with automated systems:

- Building Management Systems (BMS) display real-time air data. Operators should still verify calibration monthly.
- Portable meters are inexpensive, reliable backups when BMS fails. Record serial numbers and calibration dates.
- Data loggers can track temperature and humidity trends overnight, identifying spikes when staff are absent.
- Visual indicators (condensation on glazing, rust, or odour) remain vital; no sensor replaces an attentive nose and eye.

Operators must also maintain a calibration log noting date, method, and technician initials. Unverified sensors lead to false reassurance.

## Interpreting Results and Setting Thresholds

Raw numbers mean little without interpretation. Trends tell the real story:

- Gradual rise in humidity → Possible filter blockage or fan speed reduction
- $CO_2$ increase with stable humidity → Insufficient outdoor air intake
- Temperature swings → Faulty thermostat or poor heat recovery
- Repeated combined chlorine spikes → Inadequate water treatment or airflow stagnation

Threshold actions should be pre-defined in an Environmental Response Table. For example: If humidity > 65 % for 24 hours → Inspect drains and coils, notify maintenance, increase dehumidifier load









## Corrective Measures



Once deviations appear, the operator's task is to restore balance efficiently and record each step.

**a. Mechanical Adjustments**

- Increase air exchange rate by adjusting fan controls or opening dampers.
- Clean or replace filters to restore pressure differentials.
- Check dehumidifier set points; incorrect thermostat settings are a common oversight.
- Inspect heat-recovery coils for blockage; fouled coils trap moisture and reduce efficiency.

**b. Water Chemistry Alignment**

Because air issues often begin in the water, verify:

- Free chlorine 1–3 mg/L; combined chlorine < 0.5 mg/L
- pH between 7.2–7.6
- If chemical imbalance exists, perform breakpoint chlorination or adjust alkalinity before blaming HVAC.

**c. Operational Interventions**

- Extend ventilation run-time beyond pool hours until readings stabilize.
- Rotate staff tasks if symptoms (coughing, irritation) persist.
- Increase signage or hygiene reminders if bather load contributes to organic contamination.

**d. Communication and Reporting**

Under OHSA, any environmental condition causing worker discomfort must be reported. Document time, symptom, and corrective action. If multiple workers report irritation, escalate to the Joint Health and Safety Committee (JHSC) and Public Health Inspector.









## Scenario: The Foggy Morning

At 7 a.m., condensation clouds the viewing windows. Readings show: humidity 68 %, air 29 °C, water 28 °C, $CO_2$ 600 ppm. Operator inspects filters: partially blocked.

After cleaning and boosting dehumidifier load, humidity drops to 55 % within an hour. Log entry and photo evidence added.

**Lesson:** Even small obstructions can turn invisible vapour into visible mist. Documentation transforms guesswork into learning.

## Routine Inspection Checklist

Operators should complete this checklist monthly and file it in the Environmental Systems Logbook.

| Inspection Item | Condition | Action Required | Date/Initial |
|---|---|---|---|
| Supply and return vents clean | □ Yes □ No | | |
| Airflow direction verified | □ Yes □ No | | |
| Dehumidifier drains clear | □ Yes □ No | | |
| Filter differential pressure normal | □ Yes □ No | | |
| Corrosion or staining visible | □ Yes □ No | | |
| HVAC alarms tested | □ Yes □ No | | |
| Logbook up-to-date | □ Yes □ No | | |

Consistency matters more than perfection. Inspectors look for continuity, not one spotless week followed by silence.









## Long-Term Environmental Strategies

Beyond routine checks, facilities can invest in resilience:

- Energy Recovery Ventilators (ERVs) capture heat and humidity from exhaust air, cutting energy use by 20–30 %.
- Demand-controlled ventilation using $CO_2$ sensors adjusts airflow to occupancy levels.
- Smart monitoring dashboards alert operators to parameter drift via mobile app.
- Corrosion-resistant materials for fixtures in high-humidity zones reduce repair frequency.



*Energy Recovery Ventilator*

These measures lower costs and environmental footprint while maintaining compliance.

## Case Study: The Community Centre Turnaround

A mid-size municipal pool faced chronic odour and rust complaints. Logs revealed missing humidity data for weeks.

New manager instituted daily air quality recording, monthly technician inspections, and quarterly staff refresher training.

Within three months: combined chlorine down 60 %, HVAC energy use –15 %, no further complaints.

**Lesson:** Monitoring is not bureaucracy; it's performance management for the environment itself.









## Integration with Emergency and Maintenance Protocols

Environmental monitoring also feeds into emergency response:

- **Alarms:** Link high-humidity or $CO_2$ alarms to the facility's emergency panel.
- **Shutdowns:** If gas-heater exhaust fails or chlorine vapour leak occurs, activate ventilation purge mode before evacuation.
- **Post-incident Review:** After any chemical or air-quality event, compare logs from the prior week to identify early warning signs that were missed.



All corrective actions must be documented with date, personnel, and resolution status. This satisfies Regulation 565's requirement for continuous operational control.

## Training and Competency

Operators responsible for environmental systems must demonstrate competency through:

- Recognized certification (e.g., Pool Operator Level 1)
- Annual refresher covering HVAC basics and hazard recognition
- Familiarity with manufacturers' manuals for dehumidifiers and sensors

Training records should be stored alongside maintenance logs, evidence of ongoing due diligence.









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## Reflection Exercise

Review your facility's last seven days of environmental data.

1. Identify one parameter that fluctuated outside the target range.

2. What early warning sign could have alerted you sooner?

3. Draft a short corrective action note you would add to the logbook.









## Summary

Monitoring without reflection is measurement without meaning. A professional operator turns numbers into insight, and insight into prevention.

Environmental monitoring turns invisible risk into visible data. By measuring temperature, humidity, airflow, and contaminant levels, operators protect both people and infrastructure.

Corrective measures, from filter cleaning to staff reporting, close the loop between awareness and action. A facility that tracks its air as carefully as its water earns not only compliance but credibility.

When the environment runs quietly, without odour, fog, or corrosion, that silence is the sound of discipline.









# 9.5 Energy Efficiency and Sustainable Operations



A well-run pool isn't just about water clarity or chlorine balance. It's about the quiet hum of systems working efficiently; air, heat, and water moving in harmony with as little waste as possible. In the modern aquatic facility, sustainability isn't an optional upgrade; it's part of operational excellence.

Every kilowatt saved, every litre preserved, and every chemical dose optimized protects not only the budget but the community's environmental footprint.

This topic explores how pool operators can achieve energy efficiency and sustainability while staying compliant with Ontario's Health Protection and Promotion Act, O. Reg. 565 – Public Pools, and municipal environmental policies.

## The Case for Sustainable Pool Operation

Pools are among the most energy-intensive community facilities. Heating, ventilation, filtration, and lighting can consume up to 30% more energy than comparably sized buildings. Small operational decisions, such as when to backwash, how high to set air temperature, when to dose chemicals, add up quickly.

Energy efficiency directly supports:

- **Financial stability** — Lower utility costs, fewer mechanical failures, extended equipment life
- **Environmental compliance** — Reduced greenhouse-gas emissions and better alignment with municipal sustainability goals
- **Public trust** — Patrons increasingly expect green facilities and responsible use of community resources

The efficient pool is not the one that runs cold or dark; it's the one that runs smart.

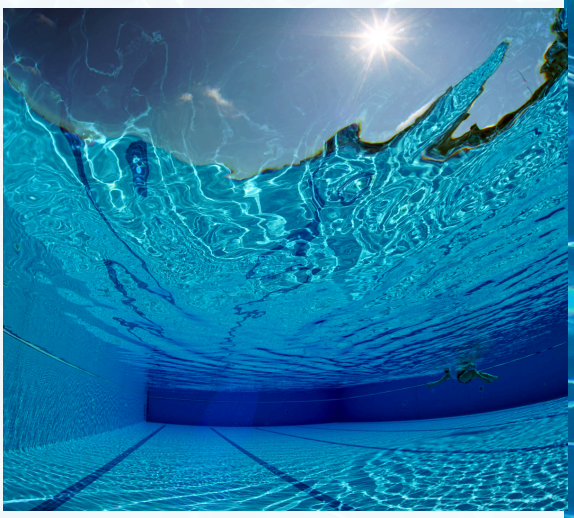








## Energy Flow in Aquatic Facilities



Energy in pools moves through three main systems:

1. **Water Heating and Circulation** – Gas or electric heaters maintain water between 27–34 °C, while pumps circulate continuously.
2. **Air Heating and Dehumidification** – HVAC maintains air 1–2 °C warmer than water, drawing substantial electrical and thermal load.
3. **Lighting and Ancillary Systems** – LEDs, UV systems, and automation consume power proportional to operating hours.

Up to 50 % of total energy loss occurs through evaporation. Each gram of evaporated water carries away heat that must be replaced. Therefore, reducing evaporation, through covers, airflow control, and balanced humidity, has the largest single impact on sustainability.

## Measuring and Benchmarking Energy Use

Operators can't manage what they don't measure. Begin with a baseline audit:

| Utility | Typical Metrics | Measurement Tools |
|---|---|---|
| Electricity | kWh per operating hour or per m² of water surface | Smart meters, utility bills |
| Gas or Heat | m³ or GJ per week | Boiler readouts |
| Water | Litres per bather or per turnover | Flow meters |
| Chemicals | Kg/L per month | Inventory logs |









## Water Conservation Strategies

Every drop saved reduces both water and heating costs.




### a. Backwash Optimization

- Backwash only when filter pressure rises 20–25 kPa above clean baseline, not by schedule.
- Install flow meters and sight glasses to confirm clarity.
- Consider filter-to-waste valves for partial cleaning rather than full-volume discharge.

### b. Leak Detection

A loss of more than 5 mm water level per day signals leakage. Dye tests or overnight shut-off checks can isolate the issue.

### c. Pool Covers

Thermal covers reduce evaporation by up to 70 % overnight. Automated reel systems make deployment feasible even in public facilities.

### d. Efficient Refilling

Top-up lines should include flow restrictors or solenoid valves to prevent overfilling and overflow.

Sustainable practice begins with awareness; watch the hose before the heater.









## Heat Recovery and Reuse

Exhaust air and wastewater are both energy-rich streams often ignored.



### a. Air Side Recovery

- Heat Recovery Ventilators (HRVs) or Energy Recovery Ventilators (ERVs) transfer warmth from exhaust to supply air.
- Maintain coil cleanliness; fouling can reduce recovery efficiency by 40 %.
- Inspect condensate drains quarterly to prevent blockages.

### b. Water Side Recovery

- Backwash water can pre-heat incoming cold water through heat exchangers.
- Solar thermal panels on rooftops supplement gas heating, particularly in summer.
- Some facilities re-circulate condenser heat from dehumidifiers to warm pool water, free energy if properly balanced.

## Scenario: The Hidden Heater

A suburban aquatic centre installed a plate heat exchanger connecting the dehumidifier's condenser to the pool heater circuit. Within six months, gas consumption dropped 18 %, and water temperature stayed rock-steady.

**Lesson:** Efficiency often hides in plain sight, the energy you already paid for.









## Smart HVAC and Automation



Automation is the silent ally of sustainability.

- **Variable Speed Drives (VSDs)** adjust pump and fan speeds to match demand. Reducing fan speed by 20 % can cut energy use by nearly 50 %.
- **Building Automation Systems (BAS)** integrate temperature, humidity, and occupancy sensors, automatically balancing air exchange rates.
- **Night Setback Modes** reduce air temperature slightly (by 1–2 °C) after hours without turning off ventilation completely.
- **Demand-Controlled Ventilation (DCV)** uses $CO_2$ sensors to modulate fresh-air intake in real time.

Operators must still supervise these systems; automation enhances efficiency, not accountability.

## Chemical and Waste Reduction

Chemical production and disposal carry environmental costs. Sustainable practice includes:

- Optimized dosing through automated feed controllers that track oxidation reduction potential (ORP).
- Bulk storage in returnable containers to reduce plastic waste.
- Safe neutralization of spent chemicals and correct pH adjustment before disposal.
- Training so staff measure accurately and avoid over-chlorination events that require flushing and refill.

These steps cut both waste and liability.









## Lighting and Electrical Efficiency



Lighting is a visible opportunity for change.

- **Replace halogen fixtures** with high-efficiency LEDs rated for humid environments (IP65 or better).
- **Install motion sensors** in mechanical rooms and storage areas.
- **Maintain reflective surfaces** around pool decks; clean luminaires quarterly to maintain brightness without extra power.
- **For daylight-rich facilities, use photocell controls** to dim artificial light when sunlight suffices.

Beyond savings, improved lighting reduces glare and enhances safety.

## Operational Scheduling and Culture

Energy efficiency lives or dies with routine. The best technology fails if switches are left on or filters ignored.

- **Align** HVAC, lighting, and circulation runtime with program schedules, not 24/7 unless required by regulation.
- **Stagger high-energy tasks:** heat pool overnight when electricity tariffs are lower; schedule backwashing in off-peak hours.
- **Create an Energy Responsibility Chart** assigning duties for each shift (e.g., "Check pool cover secured," "Log air temp differential").
- **Staff culture matters.** When operators understand that energy savings preserve budget for facility upgrades, participation follows.









## Waste Management and Recycling




Pool operations generate both solid and liquid waste: packaging, filters, chemical containers, mop water. Sustainable management includes:

- **Segregating** recyclables from contaminated materials
- **Using reusable microfiber cloths** instead of disposables
- **Contracting licensed recyclers** for used fluorescent tubes and electronic waste
- **Replacing single use testing reagents** with refillable kits where approved

Public facilities often publish annual waste diversion rates, another benchmark of accountability.

## Integrating Sustainability with Compliance

Ontario's regulatory framework doesn't prescribe energy targets, but it rewards efficiency indirectly:

- **O. Reg. 565** requires equipment to operate safely and maintain sanitary conditions. Efficient systems meet these requirements with less stress and downtime.
- The **OHSA** mandates prevention of exposure to harmful conditions; maintaining HVAC balance reduces mould and air contaminants.
- **Municipal building codes** reference ASHRAE 90.1 (Energy Standard for Buildings), guiding upgrades to mechanical systems.

Sustainability therefore aligns with compliance, not competition between "green" and "safe."









## Scenario: The Overheated Air

A community pool noticed recurring condensation despite "strong ventilation." Readings showed air temperature 4 °C higher than water.

Staff had increased it, thinking warmer meant drier. Instead, dehumidifiers overworked, humidity rose, and gas use spiked 25 %.

Resetting the air-water differential to 1.5 °C restored balance and cut costs.

**Lesson:** Efficiency is precision, not guesswork. Every degree has a dollar sign.

## Preventive Maintenance and Lifecycle Planning

Sustainability extends beyond immediate savings to asset longevity.



- **Pump Bearings and Motors:** Lubricate per manufacturer schedule; vibration wastes energy.
- **Heat Exchangers:** Descale annually.
- **Air Filters and Coils:** Clean monthly to maintain pressure differential.
- **Sensor Calibration:** Inaccurate sensors trigger wasteful compensation cycles.
- **Equipment Replacement Plan:** Document age, efficiency rating, and expected lifespan. Replace the least efficient units first when funding allows.

Regular care converts capital expense into long-term investment.









## Funding and Incentives

In Ontario, several programs (e.g., Save on Energy, Enbridge Gas Incentives) offer rebates for installing high-efficiency pumps, variable speed drives, and heat-recovery units.

Operators should:

- Keep purchase invoices and installation certificates.
- Track payback periods; most upgrades recoup cost within two to five years.
- Publicise improvements; sustainability attracts community support and grants.

Energy data can even enhance bids for municipal funding by demonstrating responsible management.









## Reflection Exercise

Consider your own or a familiar facility.

Write your answers in your learning journal.

1. Identify two high-energy systems you could optimize without capital expense.

2. Estimate potential savings in cost or carbon emissions.

3. Draft one staff initiative (e.g., “Close doors during chemical storage deliveries to retain air temperature”).









## Summary

Efficiency begins with attention. Every quiet adjustment, like closing a valve, cleaning a filter, or logging a temperature, becomes part of a larger act of stewardship.

Energy efficiency and sustainable operations are not add-ons but the backbone of responsible pool management. They reduce cost, extend equipment life, and protect both people and planet.

The certified pool operator leads this effort, not as an engineer, but as a steward balancing comfort, compliance, and conservation.









# 9.6 Applied Scenarios and Review

This capstone topic brings the pieces together: water chemistry, chloramine control, ventilation, humidity, temperature balance, monitoring, and sustainability.

You'll work through realistic situations, practise the diagnostic flow, and complete short checks to confirm competence. Use Ontario Reg. 565 expectations, OHSA duties, and ASHRAE guidance as your touchstones.

## Rapid Diagnostic Flow *(Use every time)*

**1. People First**

- **Any acute symptoms (burning eyes, coughing, dizziness)?** → Increase outdoor air, clear the deck if needed, notify supervisor/JHSC.
- **Chemical alarm?** → Follow the site emergency procedure.

**2. Numbers Now**

- **Water:** Free Cl (1–3 mg/L), total Cl, combined Cl (< 0.5 mg/L), pH (7.2–7.6), water temperature
- **Air:** Air temperature (water + 1–2 °C), RH (50–60 %), $CO_2$ (< 800 ppm), visible condensation/odour/haze

**3. Direction + Movement**

- **Tissue/Smoke Test:** Supply pushes across water → Low exhaust. Note dead zones or short-circuiting.

**4. Mechanical Checks**

- **Dehumidifier running? Filters clean? Condensate drains clear? Alarms? Fan speeds/VSDs correct?**









**5. Decide and Act**

- **High CC?** → Breakpoint chlorination + ventilation
- **High RH?** → Clear drains/filters, verify set points, temporarily boost dehumidification/air change.
- **High $CO_2$?** → Increase outdoor air fraction; check dampers/BMS.
- **Odour pocket?** → Adjust diffuser vanes, check return grille placement.

**6. Document**

Log readings, actions, personnel, and results. Schedule follow-up verification.

## Scenario Drills

Work each case using the diagnostic flow. After each scenario, compare with the model solution.

## Scenario 1: Swim Meet Spike (Evening)

**Context:** 90-minute school meet, full stands.
**Readings** at 18:00:

- Free Cl 1.4 mg/L; total Cl 2.0 mg/L → CC 0.6 mg/L
- pH 7.5; water 28.5 °C; air 29.5 °C
- RH 64 %; $CO_2$ 950 ppm near shallow end; complaints of “strong chlorine smell”

Your actions (write 4–6 steps):









## Model Approach (Condensed):

- Boost fresh air intake; increase fan speed ($CO_2$>800).
- Initiate breakpoint chlorination after the event (≈10× CC → +6 mg/L).
- Maintain pH 7.2–7.4 during shock; circulate overnight.
- Run HVAC purge 30–60 minutes post-event; hold air/water ΔT ≈1.5 °C.
- Log actions; re-test by 06:00: target CC < 0.5 mg/L, RH ≤ 60 %, $CO_2$ < 800 ppm.
- Add hygiene reminder signage before next meet (pre-swim shower).

## Scenario 2: Winter Condensation Band (Morning)

**Symptoms:** Condensation streaks on glazing 1 m above deck; rust freckles on window fasteners.

**Readings:** Water 30 °C (therapeutic program); air 31 °C; RH 67 %; $CO_2$ 620 ppm; filters: return filter DP high; dehumidifier on.

**Pitfall to Avoid:** Dropping air temperature below water to “cool things down” (would increase evaporation).

**Likely Root Causes:** Restricted airflow (dirty filters), blocked condensate drain, fouled coils, excessive infiltration at doors.

**Corrective Bundle:** Clean/replace filters; clear condensate line; schedule coil cleaning; check door sweeps; hold RH 55 %, ΔT ≈ +1–2 °C; night cover if applicable.









## Scenario 3: "Odour Corner" That Won't Quit

**Pattern:** Odour localized near shallow play area; water chemistry within target; CC 0.4 mg/L (borderline). Tissue test shows airflow up and away from surface; return grille mounted too high.

**Action:** Temporarily increase air change; re-angle supply vanes to skim surface; request contractor to add a low-level return. Consider medium-pressure UV upstream of filters to curb chloramine spikes from splash features.

## Scenario 4: UV Offline During Peak Hour

**Alarm:** UV reactor trips at 16:10.
**Water:** Free 1.8 mg/L; CC 0.3 mg/L; pH 7.4
**Air:** 30 °C; RH 58 %; $CO_2$ 700 ppm; bather load high
**Decision:** Keep pool open (chemistry and ventilation okay) while you:

- Log the outage; increase manual testing to hourly.
- Slightly increase outdoor air until UV restored.
- Call technician; record cause, repair time, and performance check on restart.

**Post-repair:** Verify CC trend over 24 hours.

## Scenario 5: Staff Symptoms, Numbers "Normal"

Two lifeguards report throat irritation; spot tests are "in range." You repeat testing at water surface and find CC in air elevated (passive badge 0.6 ppm equivalent).

**Action:** Treat as OHSA worker exposure issue: raise outdoor air, investigate dead zones, review recent shock timing (avoid during occupancy), complete incident report, bring to JHSC, schedule targeted airflow re-balancing.









## Mini Data Sets: Diagnose and Prescribe

### Data Set 1

| Metric | Value |
|---|---|
| Free Cl | 1.2 mg/L |
| Total Cl | 1.9 mg/L |
| pH | 7.6 |
| Water / Air | 28.0 °C / 29.0 °C |
| RH | 66 % |
| $CO_2$ | 680 ppm |

**Findings:** CC 0.7 mg/L (high); RH high

**Prescription (3 steps):**

- Plan breakpoint (~7 mg/L) after hours; adjust pH to 7.2–7.4.
- Clear HVAC filters/condensate; set RH to 55–58 %.
- Run purge cycle; re-test CC and RH next morning.









**Data Set 2**

| Metric | Value |
|---|---|
| Free Cl | 2.0 mg/L |
| Total Cl | 2.2 mg/L |
| pH | 7.3 |
| Water / Air | 27.5 °C / 28.8 °C |
| RH | 54 % |
| $CO_2$ | 980 ppm (spectator stands) |

**Findings:** Ventilation to stands insufficient ($CO_2$>800) while pool deck okay.

**Prescription:** Increase outdoor air fraction to spectator zone; check balancing dampers; consider DCV sensor placement; keep deck airflow pattern unchanged.

**Data Set 3 (Sustainability Angle)**

Monthly utility chart shows steady electric use; gas spiking 15 % since dehumidifier service. RH logs trend 48–50 % (slightly low).

**Hypothesis:** Dehumidifier reheating coil or heat recovery bypass configured poorly → More gas for reheat; RH set point too low

**Actions:** Return RH set point to 55 %; check reheat valve/coil and HRV damper positions; verify BAS sequence of operations.









## Hands-On Practice: Calculations

**1. Combined Chlorine (Quick):**
TC 2.3 mg/L; FC 1.6 mg/L → CC = 0.7 mg/L

**2. Breakpoint Dose (Rule of Thumb):**
CC 0.7 mg/L → Add ≈ 7 mg/L free chlorine equivalent

**3. Air–Water Differential:**
Water 29 °C; recommended ΔT 1.5 °C → Air target ≈ 30.5 °C

**4. $CO_2$ Interpretation:**
Measured 1,050 ppm with odour complaints → Increase outdoor air and verify damper actuation; re-test after 30 minutes.

## Operator Log Templates (Copy to your site logbook)

- **Daily Environmental Add-On**

Date/Time | Air (°C) | Water (°C) | RH % | $CO_2$ (ppm) | Odour/Condensation | Action Taken | Initials

- **Corrective Action Record**

Issue | Threshold Exceeded? | Immediate Action | Root Cause | Permanent Fix | Verified By/Date

- **Calibration Register**

Device | Serial # | Parameter | Due Date | Calibrated (Y/N) | By | Notes









## Practical Skills Checklist (For workplace evidence)

Have your supervisor sign off each item during your placement or current role.

□ Performs tissue/smoke test and sketches airflow arrows on a deck plan.

□ Calculates CC correctly and selects breakpoint dose.

□ Adjusts (or requests) diffuser angles to resolve a dead zone.

□ Cleans/changes return-air filters and clears condensate safely.

□ Logs environmental and chemical data with trend notes.

□ Escalates worker exposure symptoms under OHSA with documentation.

□ Aligns energy-saving steps (night purge/cover) without compromising air quality.









## Knowledge Check (10 items)

**1. The most effective single operational control for reducing heat loss from pools overnight is:**

□ a) Lowering air temperature 3 °C
□ b) Closing doors
□ c) Deploying a thermal pool cover
□ d) Reducing pump RPMs

**2. A persistent odour pocket with normal chemistry most likely indicates:**

□ a) High pH
□ b) Short-circuiting or a dead zone in airflow
□ c) Low alkalinity
□ d) Inadequate lighting

**3. Target $CO_2$ in occupied natatoriums is typically below:**

□ a) 500 ppm
□ b) 800 ppm
□ c) 1,200 ppm
□ d) 2,000 ppm

**4. If RH sits at 68 % for 24 hours, the first mechanical check should be:**

□ a) Paint the ceiling
□ b) Replace UV lamp
□ c) Inspect filters/condensate drains
□ d) Increase water temperature

**5. During breakpoint chlorination, you should:**

□ a) Raise pH to 8.0
□ b) Hold pH 7.2–7.4 and circulate continuously
□ c) Turn off ventilation
□ d) Open windows in winter









## Knowledge Check

**6. Air should be maintained at:**
□ a) 3–4 °C above water
□ b) Equal to water
□ c) 1–2 °C above water
□ d) 1–2 °C below water

**7. Repeated staff coughs with "normal" water tests should trigger:**
□ a) No action
□ b) Fragrance diffuser
□ c) OHSA reporting + targeted air testing
□ d) Lower chlorine set point to 0.5 mg/L

**8. The quickest way to prove diligence to an inspector is to produce:**
□ a) Marketing flyers
□ b) A maintenance quote
□ c) Complete environmental + chemical logs
□ d) A staff roster

**9. Adding UV typically affects:**
□ a) pH only
□ b) Combined chlorine reduction
□ c) Water temperature
□ d) $CO_2$ dilution

**10. Energy spikes after service commonly trace back to:**
□ a) Clean filters
□ b) Incorrect set points or disabled heat recovery
□ c) Fresh duct insulation
□ d) More lifeguards on duty









## Short Reflection

Write your reflection in full sentences.

1. Name one habit you will add to your daily round to catch air issues early.

2. Identify one engineering change (small or large) your facility could pursue in the next year to reduce chloramines or energy use.

3. Draft two sentences you would enter in the logbook after resolving an RH excursion.









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